700

DOUBLE PULSE GENERATOR TYPE TSA628

SER. Nº 5048

Instruction Manual

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1. INTRODUCTION

The TSA628 may be set to function as a double pulse generator within the range 2.5 c/s to 2 Mc/s or as a single pulse generator within the range 2.5 c/s to 2.5 Mc/s. Pulse-width and amplitude are variable and positive or negative polarity may be selected for the output.

In each cycle a 'pre-pulse' of selectable polarity is produced before the main pulse/s. The duration between the 'pre-pulse' and main pulse (on single pulse mode) or between the two main pulses (on double pulse mode) may be varied by use of a Delay control.

The instrument may be triggered by the internal variable frequency oscillator (free running operation), by depression of a push-button (single shot), or by the application of external signals (single shot or repetitive operation).

Silicon semi-conductor devices are employed throughout this compact pulse generator, which is designed for mains operation. Front and rear panels of the instrument are recessed in the dual-sectioned case. The unit is fitted with an adjustable stand which may be used alternatively as a carrying-handle.

2. SPECIFICATION

2.1 POWER SUPPLY

100-125V, 50-60 c/s or
200-250V, 50-60 c/s
(Voltage selection by internal adjustment: see Section 3.1)

Consumption approx. 35W

1. INTRODUCTION

2.2 FREQUENCY

2.5 c/s to 2.5 Mc/s single pulse mode
2.5 c/s to 2 Mc/s double pulse mode.

Frequency continuously variable within each of the following six ranges:

Range 1:	2.5 c/s	to	25 c/s
" 2:	25 "	"	250 "
" 3:	250 "	"	2.5 kc/s
" 4:	2.5 kc/s	"	25 "
" 5:	25 "	"	250 "
" 6:	250 "	"	2.5 Mc/s

Calibration accuracy. Range 1: 15% over entire scale
Ranges 2-6: 5% at extremities of scale, 10% at intermediate calibrations.

2.3 MAIN PULSES

Polarity : Positive or negative with respect to chassis-earth.

Amplitude: Max. 20V
Continuously variable within each of the following ranges:
0.5V, 1V, 2V, 5V, 10V, 20V
(Voltage figures for no-load condition)

Calibration accuracy.
(with Amplitude variable control set to 'CAL')
0.5 & 1V ranges: 10%
other ranges : 5%

Rise & Fall Times:

Leading edge : 10ns*
Trailing edge : 15ns*

* Nominal value between 10% and 90% points of output amplitude.

Pulse-Width: 100ns to 10ms in five decade ranges.
Continuously variable within each range.

Calibration accuracy: 5% at extremities of scale (each range),
10% at intermediate calibrations.

2.2 FREQUENCY

2.5 c/s to 2.5 Mc/s single pulse mode

2.5 c/s to 2 Mc/s double pulse mode.

Frequency continuously variable within each of the following six ranges:

Range 1:	2.5 c/s	to	25 c/s
" 2:	25 "	"	250 "
" 3:	250 "	"	2.5 kc/s
" 4:	2.5 kc/s	"	25 "
" 5:	25 "	"	250 "
" 6:	250 "	"	2.5 Mc/s

Calibration accuracy. Range 1: 1% over entire scale
Ranges 2-6: 3% at extremities of scale, 10% at intermediate calibrations.

2.3 MAIN PULSES

Polarity : Positive or negative with respect to chassis-earth.

Amplitude: 0.5V to 20V
Continuously variable within each of the following ranges:
0.5V, 1V, 2V, 5V, 10V, 20V
(Voltage figures for no-load condition)

Attenuation accuracy.
(with Amplitude variable control set to 'CAL')
0.5 & 1V ranges: 10%
other ranges : 3%

Rise & Fall Times:

Leading edge : 10ns*
Trailing edge : 15ns*

* Mean value between 10% and 90% points of output amplitude.

Pulse-Width: 100ns to 10ms in five decade ranges.
Continuously variable within each range.

Calibration accuracy: 3% at extremities of scale (each range).
10% at intermediate calibrations.

Output Impedance:

100Ω on 20V Amplitude range:

50Ω on all other ranges.

Note: To prevent ringing, the output lead should be terminated in an impedance equal to the output impedance.

2.4 DELAY

Variable Range: 100ns to 10ms in five decade ranges.
Continuously variable within each range.

Calibration accuracy: 5% at extremities of scale(each range), 10% at intermediate calibrations.

Single Pulse Mode:

Main pulse delayed with respect to pre-pulse by:- a fixed time (typically 50ns) plus the Delay control setting.

Double Pulse Mode:

First main pulse delayed with respect to pre-pulse by fixed time, typically 50ns.
Second Main pulse delayed, with respect to first Main pulse, as indicated by Delay control setting.

NB. On Delay range 0.1-1μS Delay variable-control settings less than '2' are not valid for double pulse mode. Therefore, minimum selectable delay is 200ns.

2.5 PRE-PULSE

Polarity : Positive or negative (Output a.c.-coupled)

Amplitude : 7.5V ± 2.5V (Unloaded)

Pulse-width: Between 100 & 250ns.

Output Impedance: Not greater than 1kΩ

2.6 TRIGGER SIGNALS

Trigger modes (selected by 'Frequency' switch):-

Internal

External

Manual (Push-button)

External Trigger Signal Specification:

(D.C.-coupled input)

Waveform : Sinewave, squarewave or pulse.

Amplitude: 3V to 50V peak.

Frequency: D.C. to 2.5 Mc/s.

Trigger Level: 3V. Positive or negative polarity (selectable at Frequency switch).

Min. Pulse Width: 100ns

Input Impedance : Approx. 10kΩ

2.7 TEMPERATURE RANGE

-10° to $+60^{\circ}$ Centigrade

2.8 WEIGHT & CASE DIMENSIONS

Width	:	$14\frac{1}{4}$ in. (36cm)
Height	:	$3\frac{7}{8}$ in. (10cm)
Depth (front to rear):		$10\frac{1}{2}$ in. (27cm)
Weight	:	Approx. 12lb. (5.5 kg.)

3. EQUIPMENT CONNECTION

3.1 MAINS-VOLTAGE SETTING

Before a mains supply is connected to the instrument, check that the tapping selected on the internal mains transformer is suitable for the supply voltage.

To gain access to the transformer, remove both sections of the case which are secured by two screws, one at each side of the instrument. The transformer is mounted in the left hand rear corner behind the Frequency controls.

Mains tappings on the transformer are accessible from the left hand side of the instrument. The wire connected to the OV tag should not be removed since this is the neutral supply line.

The white wire, the live line, is provided as the movable lead which should be soldered to the tap most suitable for the supply voltage.

Mains connections are provided on the transformer as indicated below.

	0V
205V	102V
225V	112V
245V	122V

--- transformer base ---

Replace and secure the case before connecting the mains supply.

3.2 CONNECTION OF MAINS SUPPLY

Having checked the voltage-setting of the mains transformer (Section 3.1), set the output polarity switch, situated below the red indicator lamp, to the OFF position. Connect the supply to the 3-core mains-lead as follows.

Red core :	Mains live
Black core:	Mains neutral
Green core:	Earth

3.3 CONNECTION OF SIGNAL LEADS

Prior to the insertion of signal leads, check that the stand is situated below the level of the three front-panel-mounted connectors.

Each connector is a coaxial socket type BNC.

The PRE-PULSE output socket is mounted near the middle of the panel with the 'main-pulse' OUTPUT socket on the right. Use of the EXT. INPUT socket (left of panel) is required only when the instrument is to be triggered by external signals.

4. OPERATING INSTRUCTIONS

4.1 INITIAL TEST

It is recommended that, prior to general use of the instrument, a test be made to check the basic operation of the TSA628 following transit. To conduct the test, terminate the main-pulse output in a 100Ω resistor and connect one beam of a double beam oscilloscope so as to observe the signals developed across the load: connect the remaining beam to the Pre-Pulse socket.

Set the TSA628 controls as indicated below.

Control		:	Setting
Frequency	switch	:	25 - 250 kc/s
"	variable control	:	10
Delay	switch	:	1 - 10μS
	variable control	:	2
Width	switch	:	0.1 - 1μS
	variable control	:	5
Amplitude	switch	:	20
	variable control	:	CAL
Pre-Pulse	switch	:	+
Single/Double mode switch		:	Double
Supply/Pulse polarity switch (on right of panel)		:	+

Check that two 10V positive pulses each of width 0.5μS and spaced 2μS apart (i.e. between leading edges) are produced after each pre-pulse. The pre-pulse should be a positive pulse of approximately 7.5V amplitude. The pre-pulse repetition frequency should be 100 k.p.p.s.

4.2 GENERAL INSTRUMENT OPERATION

4.2.1 Supply and Main-Pulse Polarity Switch

The mains supply is disconnected from the internal circuit when this switch (mounted on the right of the panel) is set to the 'OFF' position.

Switch ON the supply by turning the control to:-

\+ (for main pulses to be positive with respect to chassis-earth)

or

\- (for main pulses to be negative with respect to chassis-earth)

With the switch set to either of the above positions (+ or -) the red supply-indicator lamp, mounted above the switch, should be illuminated.

4.2.2 Mode Selector

The two-position slide-switch mounted approximately midway along the lower part of the front panel and marked 'Single-Double' serves as mode selector. The setting of the switch indicates the number of 'main pulses' generated after each 'pre-pulse'.

4.2.3 Pre-Pulse Output

A two-position slide-switch and an a.c.-coupled coaxial socket are provided for the Pre-Pulse output; they are mounted below the Delay controls.

The switch serves as pre-pulse polarity selector: the pre-pulse is negative-going when the switch is in the '-'position and positive-going when the switch is in the '+' position.

4.2.4 Frequency & Trigger Selector

The dual control marked 'Frequency' serves as both trigger and frequency selector.

Manual Trigger:

The outer control (large knob, with T-shaped panel-markings) is a ten-position switch. Manual trigger operation is selected

when the switch is set to the first position (i.e. the extreme anti-clockwise setting). The instrument is then triggered, for single shot operation, each time that the Manual push-button is depressed. With this switch setting the inner control is inoperative.

External Trigger:

When the outer control is set to the second or third position, the instrument is triggered by signals applied at the socket marked EXT. INPUT.* The inner control is inoperative on each of these switch settings.

The pulse generator is triggered by:-

(i) Negative-going external input signals when the switch is set to '-' (i.e. 2nd position)

(ii) Positive-going external input signals when the switch is set to '+' (i.e. 3rd position).

Before using the External Trigger facility refer to Note 2 below.

Internal Trigger:

N.B. Should the switch (outer Frequency control) be set to the unmarked fourth position no output signals will be produced. The position serves only to space adjacent switch-markings.

For internal trigger operation the band 2.5 c/s to 2.5 Mc/s is covered in six consecutive ranges by the fifth to tenth positions of the switch. For each range, the inner control (small knob, with black panel-markings) serves as a variable frequency control.

Example of Control Operation:-

With the switch set to the seventh position, the figures (250 c/s) to the left of the T-shaped position-mark indicate the

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* For signal specification refer to Section 2.6

lower limit of the selected frequency range, whilst those to the right (2.5 kc/s) indicate the upper frequency limit. In this case the lowest calibration mark (2.5) of the inner control corresponds to 250 c/s, whilst the highest calibration mark (25) corresponds to 2.5 kc/s: any trigger frequency between these limits may therefore be selected by use of this inner control.

Notes: (1) With the 250 kc/s - 2.5 Mc/s frequency range selected for use in the Double pulse mode, the output pulse specification (Section 2.3) may not be valid for variable-frequency-control settings greater than 20 (i.e. 2 Mc/s : see Section 2.2)

(2) For Single or Double pulse mode, the interval between consecutive trigger signals * should not be less than:-

Delay setting or Pulse Width setting

4.2.5 Delay Control

In the Double pulse mode, the setting of the dual control marked 'Delay' indicates the duration between the leading-edge of the first 'main pulse' and the leading-edge of the second 'main pulse' generated in each cycle.

For the Single pulse mode, the duration between the leading-edge of the 'pre-pulse' and the leading-edge of the 'main pulse' in each cycle is approximately 50ns plus the time indicated by the Delay control setting.

Delay times of 0.1μS to 10ms are covered in five consecutive ranges by the outer control (large knob, with T-shaped panel-markings). For each range the inner control (small knob, with black panel-markings) serves as variable control. Thus,

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* i.e. the reciprocal of Frequency setting in the case of internal trigger operation.

with the outer control set to the fourth position, the variable control may be used to select any delay time from 100μS (corresponding to panel-mark '1') to 1ms (corresponding to panel-mark '10').

Notes: (1) For Single pulse mode the Delay setting or Width setting should be less than the interval between consecutive trigger signals*.

(2) For Double pulse mode the Delay setting should be less than the interval between consecutive trigger signals and the Width setting should be less than the Delay setting.

4.2.6 Width Control

The setting of the dual control marked 'Width' indicates the duration of each 'main pulse'.

This control is physically identical to, and may be set in the same manner as, the Delay control.

Notes: (1) For Single pulse mode the Width setting should be less than the interval between consecutive trigger signals.

(2) For Double pulse mode the Width setting should be less than the Delay setting.

4.2.7 Amplitude Control

The amplitude of each 'main pulse' is dependent upon the setting of the dual control marked 'Amplitude Volts'; the control comprises a six-position range-selector-switch (large knob withradial panel-markings) and a variable control (small knob with black panel-markings).

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* i.e. the receiprocal of Frequency setting in the case of internal trigger operation.

With the variable control turned fully clockwise the amplitude of each 'main pulse' is indicated, for the no-load condition, by the switch-setting (volts). With any switch-setting, the pulse amplitude may be progressively reduced by anti-clockwise rotation of the variable control : 'Min' setting corresponds to approximately one-third of the range setting, e.g. with the switch set to 20V and the variable control at 'Min', the no-load output amplitude is approximately 7V.

Note: With a load impedance equal to output impedance of selected range, output amplitude should be half the no-load amplitude. Output impedance: 100Ω ± 5% on 20V range; 50Ω ± 5% on other ranges.

5. MAINTENANCE

5.1 CASE REMOVAL

CAUTION. Before removing the case of the instrument disconnect the mains cable from the supply. Should it be necessary to operate the unit with the case removed, e.g. during servicing or maintenance of the instrument, due care should be exercised to ensure that no physical contact is made with exposed connections, particularly mains connections in the vicinity of the supply-switch and mains transformer.

Both sections of the case may be removed when the two fixing screws, situated one at each side of the unit, have been withdrawn. Removal of the case should give sufficient access to the instrument for most fault finding and maintenance purposes. The instrument may, however, be partly dismantled to give greater access to certain components and sub-assemblies : should this be required refer to Section 7.

5.2 INDICATOR LAMP REPLACEMENT

The indicator lamp is accessible from the top of the instrument. Holding the rear of the lamp housing, gently withdraw the lamp assembly from its mounting grommet in the secondary front panel. Unscrew and replace the lamp; then insert the lamp assembly into the grommet.

Replacement lamp:- 12V 1W tubular LES 679
Venner Part No. Z22749

If it becomes apparent that lamp failure is caused by a fault condition rather than prolonged use (e.g. manifested by early failure of the replacement lamp) then the lamp circuit should be checked, refer to Section 8.

5.3 FUSE REPLACEMENT

Four cartridge fuses are incorporated in the instrument; they are mounted on the printed circuit power supply board type PCA 628/11, situated behind the rear panel. All four fuses are held in clips attached to the component side of the board. The positions and ratings of the fuses are shown on diagram S63/51 (Fig.1). Fuse FS3 is accessible from the top of the instrument; the remaining fuses are accessible from the bottom.

Replacement fuses are as follows.

Fuse		Rating	Venner Part No.
FS1	(mains supply)	0.25A Anti-surge	Z50291
FS2,3,4	(internal d.c. supplies)	0.5A	Z19831

Should it become apparent that a fault condition has developed (e.g. maifested by failure of the replacement fuse) the power supply circuit should be checked, refer to Section 8.

6. ALIGNMENT

6.1 PREPARATION

The instrument is aligned and tested after manufacture; therefore, in normal circumstances, the settings of the internal preset controls should not be altered.

If at some time (e.g. after the instrument has given long service) it is found that the performance of the TSA628 no longer conforms to the specification, re-alignment of the instrument may be carried out in accordance with the instructions given below.

If a distinct fault is known to exist, this should be located and rectified before alignment is commenced (refer to Section 8).

For the purpose of alignment, the following equipment is required.

Resistor of value 100Ω.

Double-beam oscilloscope possessing bandwidth of 50 Mc/s or greater.

Recommended types:- Tektronix type 581A

Hewlett Packard type 175A.

Universal meter

Recommended type :- 'AVO' Model 8.

Frequency Meter capable of 2.5 Mc/s measurement.

6.2 ALIGNMENT PROCEDURE

In the following text reference is made to certain layout drawings on which lettered and numbered axes appear. The position of a component is indicated in the text by reference to two ordinates (e.g. 'B5'); the position of the component may be found, on the particular diagram, in the square formed by the intersection of the two ordinates.

6.2.1 General Connections & Settings

Note: For case removal refer to Section 5.1.

(i) Check that transformer-tapping is correctly positioned for supply voltage (refer Section 3.1)

(ii) Connect coaxial signal lead to main-pulse output socket of TSA628 and terminate coaxial lead in a 100Ω resistor. Connect beam-1 of a double-beam 50 Mc/s bandwidth oscilloscope, so as to observe waveform of voltage across resistor.

(iii) Connect beam-2 of oscilloscope between chassis-earth and switch SA wafer 1 stators 5 to 10 (see diagram S63/52 'Reference Point A')

(iv) Using a coaxial lead, connect TSA628 Pre-pulse output socket to external trigger input socket of oscilloscope: set oscilloscope to 'External Trigger Positive'.

(v) Connect a frequency meter (capable of measuring to 2.5 Mc/s) between chassis-earth and switch SA wafer 1 stators 5 to 10 (see diagram S63/52 'Reference Point A').

(vi) Set TSA628 pre-pulse switch to '+'.

(vii) Set Amplitude switch (outer control) to '20' and set main pulse polarity switch to '+'.

(viii) Turn preset controls RV21 and RV22 (refer to diagram S63/50 locations C11 & D10 respectively) fully clockwise; then turn each control anti-clockwise through approximately 70°.

Switch ON the TSA628 : the indicator lamp should light.

6.2.2 Power Supply

(a) Using a suitable voltmeter (e.g. 'AVO' Model 8 set to the 25V a.c. range) measure potential between tags of lamp holder: potential should not be greater than 11.5V.

(b) Set voltmeter to 25V d.c. range and connect as follows:-

Meter '-' to pin 1 on printed circuit board PCA628/12, refer to diagram S63/53 Fig 1.

Meter '+' to chassis-earth

(c) Adjust control RV2 (refer to diagram S63/51 Fig 1 location D11) for 10V indication on meter. Remove the meter.

(d) Connect meter as follows:-

Meter '+' to pin 2 on printed circuit board PCA628/12 refer to diagram S63/53 Fig 1.

Meter '-' to chassis-earth

(e) Adjust control RV1 (refer to diagram S63/51 Fig 1 location A8) for 11.5V indication on meter. Remove the meter.

(f) Connect meter as follows:-

Meter '+' to switch SE wafer 1b stator 2 (see diagram S63/52 'Reference Point B')

Meter '-' to chassis-earth

(g) Set Amplitude variable control (inner control) fully clockwise; then adjust control RV5 on amplitude printed circuit board PCA628/13 (see diagram S63/52) for 21.5V indication on meter.

(h) Turn Amplitude variable control fully anti-clockwise: then adjust control RV4 on amplitude printed circuit board PCA628/13 (see diagram S63/52) for 8V indication on meter.

(i) Repeat procedures (g) and (h) until the 21.5V and 8V indications are obtained for max. and min. settings of amplitude variable-control without further adjustment of RV5 and RV4 being necessary

Remove the meter.

6.2.3 External Input Trigger Level:-

(i) Set Frequency/Trigger selector to 'Ext. Input +'

(ii) Connect voltmeter (e.g. 'AVO' Model 8 set to 10V d.c. range) between centre-pin and shell of Ext. Input socket; adjust control RV10 (see diagram S63/50 location E4) for meter indication of zero potential measured finally on meter range 2.5V d.c. Remove the meter.

6.2.4 Oscillator:-

(a) Switch Frequency selector to 2.5 - 25 kc/s range; adjust RV25 (see diagram S63/50 location A3) for 3.5 to 4.5V peak-to-peak unclipped sinusoidal output on oscilloscope beam -2.

(b) Set each of the following potentiometers to the mid-track position:-

RV6	(see diagram	S33/50	location	C3)
RV7	("	"	"	"	C3)
RV23	("	"	"	"	C2)
RV24	("	"	"	"	C1)

(c) Adjust variable Frequency control for frequency meter indication of 2.5 kc/s $\pm$ 12 c/s.

Note amplitude of oscilloscope beam - 2 waveform.

(d) Mark on variable Frequency control-knob should coincide with 2.5 black calibration mark. If necessary, slacken grub screw (taking care that frequency is not altered) and set knob as required; lightly tighten grub screw.

(e) Set variable Frequency control knob to '25' and adjust RV6 & RV23 (see diagram S63/50 locations C3 & C2) for frequency meter indication of 25 kc/s $\pm$ 125 c/s and same amplitude as in (c) above.

(f) Repeat procedures (c) to (e) until required frequencies are obtained at calibration marks 2.5 & 25 without further adjustments being necessary: firmly tighten grub screw.

(g) Set Frequency switch to 250 kc/s - 2.5 Mc/s range and variable control to 2.5: adjust concentric capacitors C16 & C18 (see diagram S63/52) until frequency meter indication of 250 kc/s ± 1.25 kc/s is obtained with same amplitude as in (c) above.

(h) Set variable Frequency control to '25': adjust RV7 and RV24 (see diagram S63/50 locations C3 & C1) until frequency meter indication of 2.5 Mc/s ± 12.5 kc/s is obtained with same amplitude as in (c) above.

(i) Repeat procedures (g) and (h) until required frequencies are obtained at calibration marks 2.5 and 25 without further adjustments being necessary.

(j) Remove leads of frequency meter and oscilloscope beam-2 from TSA628.

6.2.5 Width & Delay Circuit:-

(i) Check that knobs of Delay and Width variable controls are secured so that the amount of off-scale movement preceding calibration mark '1' is equal to that following '10'.

(ii) Select Single pulse mode and set Frequency to 2.5 kc/s.

(iii) Set Delay and Width controls as follows:-

Switch : 10 - 100µs range

Variable control: 10

(iv) A pulse should be displayed by oscilloscope beam-1: adjust RV20 (see diagram S63/50 location E8) for pulse width 100µs ± 3%.

(v) Set Width variable control to '1': adjust RV17 (see diagram S63/50 location F8) for beam-1 pulse width 10µs ± 3%.

(vi) Repeat procedures (iv) and (v) until required pulse widths are obtained, without adjustment, for 10 and 1 settings of Width variable control.

(vii) Select Double pulse mode.

(viii) With Delay and Width controls set thus:-

	Delay	Width
Switch :	10-100μs range	10-100μs range
Variable Control:	10	1

check that two pulses, each of width 10μs, are displayed by oscilloscope beam-1 and adjust RV15 (see diagram S63/50 location E6) for 100μs ± 3% duration between leading edges of pulses.

(ix) Set Delay and Width controls as below.

	Delay	Width
Switch :	10-100μs range	1-10μs range
Variable control :	1	1

(x) Adjust RV12 (see diagram S63/50 location F6) for 10μs ± 3% duration between leading edges of pulses.

(xi) Adjust RV18 (see diagram S63/50 location F8) until beam-1 pulses are each 1μs ± 3% wide.

(xii) Repeat procedures (viii) to (x) until required inter-pulse durations are obtained, without further adjustment, for '10' and '1' settings of Delay variable control.

(xiii) Set Frequency controls to 25 kc/s and Delay and Width controls as below.

	Delay	Width
Switch :	10-100μs range	0.1-1μs range
Variable control:	1	10

Adjust C17 (see diagram S63/52 until beam-1 pulses are 1μs ± 3% wide.

(xiv) Set Width variable control to 1: adjust RV19 (see diagram S63/50 location E8) to give 0.1µs ± 3% wide pulses.

(xv) Repeat procedures (xiii) and (xiv) until required pulse widths are obtained, without adjustment, for settings '1' & '10' of Width variable control.

(xvi) Set Delay and Width controls as below.

	Delay	Width
Switch :	1-10µs range	0.1-1µs range
Variable control:	1	1

Adjust RV13 (see diagram S63/50 location F5) for 1µs ± 3% duration between leading edges of pulses.

(xvii) Set Delay switch to 0.1-1µs range and Delay variable control to 10: adjust C19 (see diagram S63/52) for 1µs ± 3% duration between leading edges of pulses.

(xviii) Turn Delay variable control to '2'; adjust RV14 (see diagram S63/50 location E5) for 0.2µs duration between leading edges of pulses.

(xix) Repeat (xvii) and (xviii) until required inter-pulse durations are obtained, without adjustment, for settings '10' & '2' of Delay variable control.

6.2.6 Output Pulse:

(a) Set Frequency to 250 kc/s, Delay to 0.5µs, Width to 0.1µs. Select double-pulse mode and set output amplitude to 20V, polarity +.

(b) Observing beam-1, adjust control RV21 (see diagram S63/50 location C11) for fastest pulse rise-time obtainable without fall-time (trailing-edge) exceeding 20ns.

(c) Select negative output polarity. Observing beam-1 adjust control RV22 (see diagram S63/50 location D10) for fastest pulse rise-time obtainable without fall-time exceeding 20ns.

(d) If procedures 'b' and/or 'c' produce a change in the 0.1µs pulse width, readjust pulse-wdith controls in accordance with Section 6.2.5 procedures (xiii) to(xv).

7. INSTRUMENT DISMANTLEMENT

Note: For case removal refer to Section 5.1.

7.1 POWER SUPPLY BOARD (PCA 628/11)

Access to connections on the power supply board may be gained by removal of the rear panel : unscrew (by anti-clockwise rotation) and remove the two cable stowage knobs from the projecting mounting-screws and free the panel from the mains cable grommet situated in a slot at one end. The panel may then be lifted away from the unit to expose the printed circuit power supply board.

Should it be necessary to detach this board, withdraw the fixing screws marked 'A' in Fig 2 of diagram S63/51; then, supporting the sub-assembly by holding the transformer, withdraw the screws marked 'B' in Fig 2.

For complete detachment of the board it will be necessary to disconnect a number of leads which connect the sub-assembly to the main circuit of the instrument: terminations should be carefully noted before the leads are disconnected.

The power supply board may be withdrawn via the top of the instrument.

7.2 MAIN BOARD (PCA 628/12)

Connections on the main printed circuit board are accessible from the base of the unit. This board is secured to the main frame by five screws inserted from the underside of the instrument. For general maintenance, removal of this board should not be necessary. It is recommended that the instrument be returned to Venner Electronics Limited if for any reason a major repair is required.

7.3 AMPLITUDE CIRCUIT BOARD (PCA 628/13)

This printed circuit board is secured to a bracket behind the front-panel-mounted Amplitude controls. The board is secured by two screws and is accessible from the top of the instrument.

If removal of the board is required, terminations should be noted before the leads are disconnected.

7.4 ATTENUATOR BOARD (PCA 628/14)

The attenuator printed circuit board is mounted on the rear of the main-pulse output socket which is accessible from the base of the instrument. To detach the board, first note the terminations of the six leads which link it to the main circuit; then disconnect the leads, remove the nut of the main-pulse output socket and withdraw the board.

7.5 FREQUENCY & DELAY BOARDS (PCA628/15)

Two printed circuit boards type PCA628/15 are incorporated in the instrument, one is mounted on the switch assembly of the Freqeuncy controls, the other on the switch assembly of the Delay controls. For switch removal refer to Section 7.7.

7.6 SLIDE SWITCHES & PUSH-BUTTON

To remove the push-button or either of the slide switches (i.e. pre-pulse switch or mode-selector) it is necessary to first detach the front panel as follows.*

Set each front panel knob to the extreme anti-clockwise calibration mark; then remove the knobs after releasing their grub-screws. Withdraw the four chromium plated front panel fixing screws (situated one in each corner) and lift away the panel from the front of the instrument.

The nut of the push-button and fixing screws of the slide switches, will then be accessible from the front of the unit. Before leads are disconnected from these components, their terminations should be noted.

7.7 ROTARY CONTROLS

To remove a rotary switch, first set its control knob/s to the extreme anti-clockwise calibration mark; then remove the knob/s after releasing the grub screw/s.**

Remove the fixing nut (around the bush of the switch) using a flat spanner inserted from the top of the instrument (or from the side, in the case of the main-pulse-polarity and Frequency controls). Alternatively a box spanner may be used to unscrew the fixing nut, but use of this tool should be avoided if possible since removal of all control knobs and detachment of the front

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* Note: (1) Detachment of the panel necessitates removal of the inner dual-control-knobs: see also Note 2 below.

** Note: (2) When replacing the inner knob of a dual control it is essential that it is carefully repositioned if the calibration accuracy of the instrument is to be maintained. Calibration checking is treated in Section 6.

panel will be necessary. (For detachment of panel and removal of control knobs refer to Section 7.6.)

Removal of the main-pulse-polarity and supply switch necessitates detachment of the supporting bracket which is secured by two screws to a vertical member at the right side of the unit.

In order to withdraw the Frequency switch-assembly it is necessary to remove the power supply board, refer to Section 7.1.

Before disconnecting the leads from a switch assembly their termination points should be carefully noted.

Upon completion of any repair involving replacement or alteration to the setting of a component, alignment of the instrument should be checked in accordance with Section 6.

7.8 HANDLE MECHANISM

The friction devices at the handle bearings are adjusted during instrument manufacture and henceforth should not be altered.

The handle and its mechanism constitute a removable sub-assembly which is secured at each side of the instrument by two round-head screws (inserted from within the unit).

Should the handle or its mechanism be damaged or become faulty, the sub-assembly may be detached and returned to Venner Electronics Limited for rectification.

To detach the sub-assembly remove the four round-head screws; then gently pull apart the side bars of the handle just sufficient to allow the assembly to be withdrawn from the frame of the instrument.

7.9 FRONT & REAR PANELS

Front and rear panel removal is treated in Sections7.6 and 7.1 respectively.

8. FAULT FINDING

8.1 GENERAL INFORMATION

Note: The procedures prescribed for fault finding are not exhaustive but should cover most fault conditions encountered. Random adjustment of the internal preset controls should not be made in an attempt to clear a fault, otherwise conditions which complicate fault tracing may be introduced.

The alignment procedure presented in Section 6 may be carried out if a fault of a minor nature, and symptomatic of mis-alignment, should develop.

For other fault conditions select from Section 8.2 the sub-heading which corresponds to the nature of the fault and carry out the prescribed procedure given thereunder.

If a fault is present only on one range of a rotary switch, fault finding may be immediately localised to wafers of that particular switch, and furthermore, on each wafer, to components peculiar to the stator selected when the switch is set to the faulty range.

The fault finding procedure is arranged so that faults of a general nature may be quickly traced to a particular circuit-section.

The circuit of the instrument is shown by two diagrams which are provided at the rear of this manual; diagram ES66/12 shows the main circuit arrangement whilst diagram ES66/11 shows the power supply circuits.

Functional descriptions of the various circuit-sections are given in Section 9 of this manual. Component values and location references are listed in Section 10.

For case removal see Section 5.1.

Notes on Fault Correction :-

(a) Components should not be removed from the unit unless it is necessary to do so. When removing or inserting a component a heat sink (e.g. pliers) should be used to prevent damage to component due to heat from soldering iron.

(b) When removing or inserting components ensure supply is 'OFF'; otherwise high voltage surges may damage transistor-junctions.

(c) When heating connections on printed-circuit board, board should be in horizontal plane to prevent solder from flowing across printed circuit.

(d) After changing component/s check calibration and operation of instrument; if incorrect re-align (see Section 6).

8.2 FAULT FINDING PROCEDURE

Note: The instruments recommended in Section 6.1 (voltmeter and oscilloscope) should be sufficient for general fault finding, but additional instruments may be necessary in certain cases e.g. component testing.

Set the controls of the TSA628 as follows.

Frequency	Delay	Width	Mode	Pre-Pulse	Amplitude
100 kc/s	2µS	0.5µS	Double Pulse	+	+20V

The main-pulse output should be terminated in a 100Ω resistor.

Select from below the sub-heading which corresponds to the nature of the fault and carry out the procedure prescribed thereunder.

(1) Frequency Variable-control : Incorrect Function.

Proceed in accordance with Section 8.2.1.

(2) Delay Variable-control: Incorrect Function.

Proceed in accordance with Section 8.2.5.

(3) Width Variable-control: Incorrect Function.

Proceed in accordance with Section 8.2.6.

(4) Amplitude Variable-control : Incorrect Function.

Proceed in accordance with Section 8.2.9.

(5) No Main-Pulse Output

Should no main output pulses be produced for + and - settings of the polarity switch on both Single and Double pulse modes, proceed as follows.

(a) Check that positive pre-pulses are produced at Pre-Pulse output socket.

If pulses are present pass to procedure (f) below.

If pulses are not present continue with procedure (b).

(b) With voltmeter check H.T. supplies:-

Check point	:	Required potential with respect to chassis-earth.
Drg. S63/53, Fig.1, Pin 1	:	-10V
Drg. " " " Pin 2	:	+11.5V
Drg. S63/52 Reference point B:		+21.5V

Should one or more of the above supplies be incorrect or absent, check in accordance with Section 8.2.9, then proceed with (c) below.

(c) With correct H.T. supplies, check oscillator (and make adjustments if necessary) in accordance with Section 8.2.1.

(d) With correct oscillator conditions, check waveform at VT15 collector (WF11), see Section 8.2.2; if correct, check circuits of VT17 and VT18 see Section 8.2.3.

(e) If waveform at VT15 collector is incorrect, check circuits of VT13, VT14 & VT15 see Section 8.2.2. If no fault is found proceed with (f) below.

(f) Check waveform WF30, see Section 8.2.6.

Incorrect: Check VT25 circuit (Section 8.2.5) and circuit of MR32 & VT26 (Section 8.2.6).

Correct : Check VT27 collector (Section 8.2.6) and if incorrect check Width circuit (Section 8.2.6). If VT27 collector correct, check VT28 circuit and switch SE2a (Section 8.2.7). If VT28 circuit correct, check output stage as in Section 8.2.8.

(6) No 2nd Main-Pulse on Double Pulse Mode

Check VT20 circuit, MR25 and switch SF (see Section 8.2.3).

(7) Mains Pulses Absent on Single Pulse Mode

If main pulses are produced on Double pulse mode but are absent on Single pulse mode, proceed as below.

(a) Check VT23 collector circuit (Section 8.2.5). If correct check circuits of VT24 and VT25 and MR31 (Section 8.2.5).

(b) If circuit of VT24, VT25 & MR31 are correct:-

Check circuit of VT21 (Section 8.2.3) and if this is correct check Delay circuit (Section 8.2.5).

(8) Main Pulses Obtainable in Positive Polarity Only

(a) Set main pulse polarity switch to '-'.

(b) Check H.T. potential (with respect to chassis-earth) at junction of R102 & C66; this should be -21.5V.

H.T. Incorrect:- Check switch SE1b & SE1c and power supply as in Section 8.2.9.

H.T. Correct:- Check that waveform WF37 (refer to Section 8.2.7) is present at switch SE2a stator 3 (see dgm. S63/52). If waveform absent or incorrect, check switch SE2a. If waveform is correct, check that waveform WF45 is present at VT33 collector (see Section 8.2.8) and that similar signals are present at board PCA628/13 (see dgm. S63/52) pins 4 & 3.

(9) Main-Pulses Obtainable in Negative Polarity Only

(a) Set main pulse polarity switch to '+'

(b) Check H.T. potential at junction of R95 & C63 with respect to chassis-earth; this should be +21.5V.

H.T. Incorrect:- Check switch SE1b & SE1c (dgm S63/52) and power supply as in Section 8.2.9.

H.T. Correct:- Check that waveform WF37 (refer to Section 8.2.7) is present at switch SE2b stator 2 (see dgm S62/52). If not present, check switches SE2a & SE2b, and VT29 circuit, see Section 8.2.7.
If waveform WF37 is present at SE2b stator 2, check that waveform WF41 (refer Section 8.2.8) is present at VT31 collector and at board PCA628/13 (see dgm S63/52) pins 4 & 3.

(10) Pre-Pulse Obtainable in Positive Polarity Only

Check switch S9 and VT19 circuit as in Section 8.2.3.

(11) Instrument Not Responsive to:-
Positive External Signals or Push-button Operation
(Triggered by Negative External Signals)

Check VT16 circuit (Section 8.2.4) and trigger circuit (Section 8.2.2.).

(12) Instrument Not Responsive to External Input Signals of Either Polarity

Check trigger circuits as in Section 8.2.2.

(13) Instrument Not Responsive to High Frequency External Input Signals.

Check C38 (for open-circuit lead etc) if correct see Section 8.2.2.

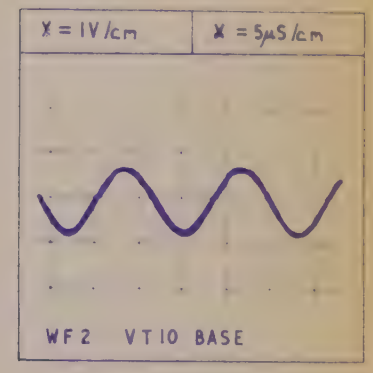
(14) Power Supplies Faulty

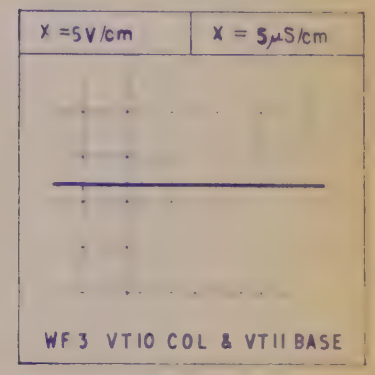
Check as in Section 8.2.9.

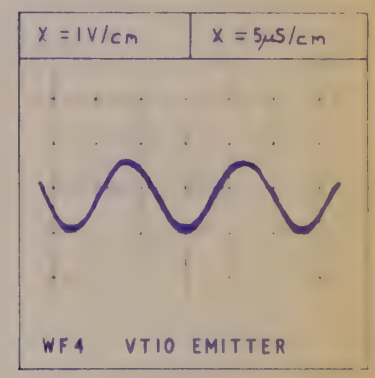
8.2.1 Oscillator

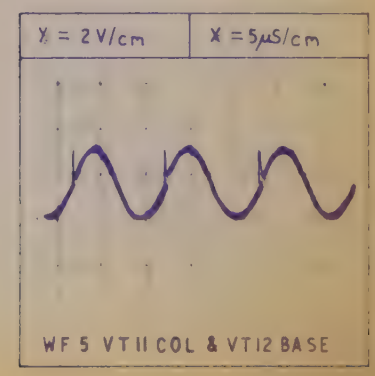
Check oscillator output developed across R39; this should be sinusoidal and of amplitude 3.5 to 4.5V peak-to-peak, see page 30 waveform (WF)1.

Fault Symptoms	Procedure
(a) Excessive Amplitude	: Check thermistor TH2 for possible open circuit.
(b) Low Amplitude	: Check thermistor TH1 for possible open circuit.
(c) No Oscillation (All Ranges)	: (i) Check H.T. supplies, see Section 8.2.9.
	(ii) Check thermistor TH1 for possible open circuit.
	(iii) Observe waveforms at VT10,11, & 12, see waveforms WF2-5 page 30.
	(iv) Check connections of leads from switch SA(dgm.S63/52) to main board.
	(v) Check potentiometers RV8 & RV9 (Drg.S63/52) and associated leads.
(d) Squegging	: Follow alignment procedure (Section 6) and ensure that oscillator output, developed across R39 is 3.5 to 4.5V peak-to-peak.









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WAVEFORMS 1-5

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(e) Incorrect Function of Frequency Variable-control.

Check potentiometers RV8 & RV9 (Drg. S63/52) and associated leads.

8.2.2 Trigger Circuit

(a) Set Frequency switch to 'Ext. Input +'; set mode selector to 'Single'.

(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

Check	:	Procedure for Fault
(i) Centre-pin of Ext.Input socket: 0V		Check setting of RV10 (refer to Section 6.2.3). Check VT13, MR15, MR16, R42 & R43. Inspect switch SA1 (Drg. S63/52) for faulty operation.
(ii) VT13 emitter: -0.7V $\pm$0.1V		Check R45 and VT13.
(iii)VT14 collector: +9.5V $\pm$ 0.5V		Low voltage: inspect SA2 (Drg. S63/52) for open-circuit, check R46 and test VT14(leakage).
(iv) VT15 collector: approx. +1.5V (& VT14 emitter)		Collector voltage high: check R49, R50 and VT15.
Check following d.c. conditions while holding Manual push-button depressed.		
(v) VT14 collector : approx.+1V) VT15 collector : +11.5V) VT14 emitter : approx. +1V)		No change in d.c. levels when push-button is pressed. Check that VT13 emitter potential swings positive when push-button is depressed; for no positive swing check push-button circuit. If VT14 collector voltage does not fall to approx.+1V when push-button is depressed check VT14 emitter voltage (approx.+1V) and check transistor (VT14).

If VT14 collector level changes correctly but VT15 collector level does not change correctly, check R51 and check VT14 for leakage. Check also C39 for leakage or short-circuit.

(vi) Release the push-button. Change Frequency switch setting from 'Ext Input +' to 'Ext Input -'. The d.c. conditions of (iii) and (iv) above, should change to the values shown in (v). No change in d.c. conditions:- Check MR18 & MR19 and operation of switch SA2 (Drg. S63/52).

(c) Set Frequency to 100 kc/s. Check waveforms as shown on page 33 (i.e. waveforms WF6 to WF11). VT15 output:- If duration of negative-going edge of VT15 output is slow compared with waveform WF11 check C38 for possible open-circuit connection.

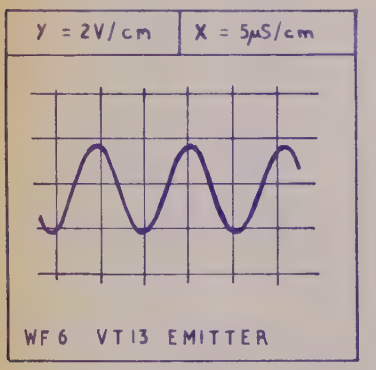
8.2.3 Shapers, Emitter Follower & Pre-Pulse Output

(a) Set Frequency switch to 'Ext Input -'

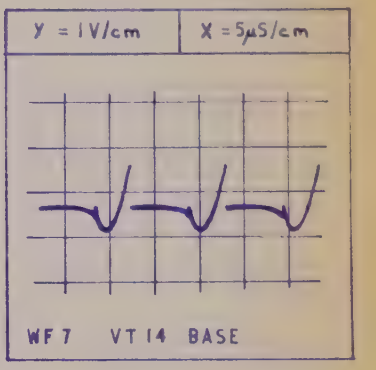
(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

(N.B. Voltage values with respect to chassis-earth)

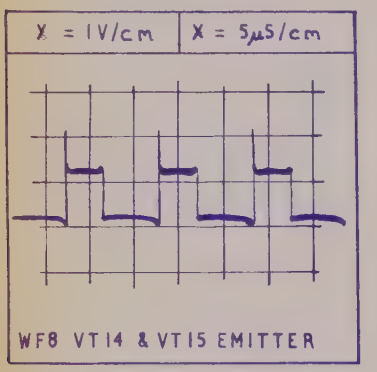
Check	Procedure for Fault
(i) VT17 collector: not greater than +0.5V	Greater than +0.5V: check R55, MR21, MR22 and VT17.
(ii) VT18 emitter: not greater than +0.5V	Greater than 0.5V: check VT18
(iii) Centre-pin Pre-Pulse socket: 0V VT19 collector: +11.5V VT20 collector: +11.5V VT21 collector: +11.5V	Low collector voltages: check VT19 20,21 for leakage.



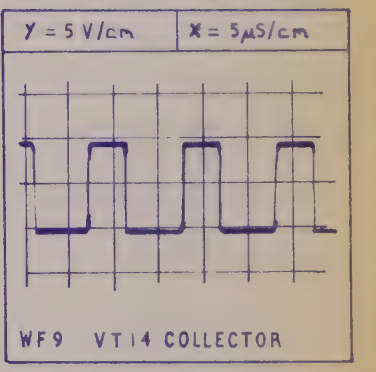
WF 6 VT 13 EMITTER



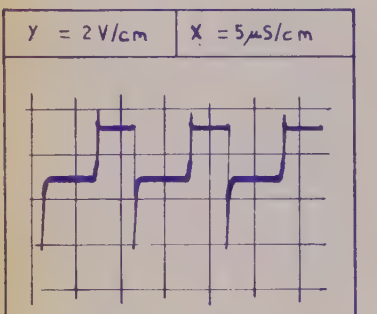
WF 7 VT 14 BASE



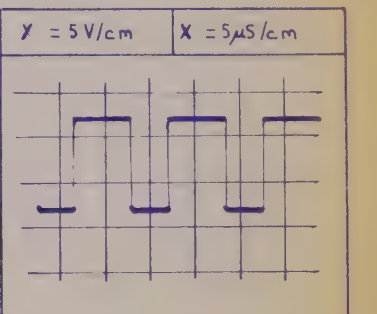
WF 8 VT 14 & VT 15 EMITTER



WF 9 VT 14 COLLECTOR



WF 10 VT 15 BASE



WF 11 VT 15 COLLECTOR

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WAVEFORMS 6-11

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(c) Set Frequency to 100 kc/s Check waveforms as shown on page 35 (i.e. waveforms WF12 to WF20).	: VT17 pulse too wide compared with waveforms WF12 & 13. Check R55, MR21 MR22 & C40. VT19, VT20, & VT21 pulses too narrow or too wide compared with waveforms WF15-20; check components in base circuits of transistors.

8.2.4 Inverter

(a) Set Frequency switch to 'Ext. Input +'

(b) Check the following d.c. condition and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

Check	Procedure for Fault
(i) VT16 collector +11.5	Low collector voltage; check VT16 for leakage.
(c) Apply 100 kc/s signals* to Ext. Input socket and check waveforms as shown on page 37 (i.e. waveforms WF21 & 22).	Pulses too wide or too narrow compared with waveforms WF21 & 22; check base circuit components of VT16.

8.2.5 Delay Circuit & Shapers

(a) Set Frequency switch to 'Ext. Input -'

(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

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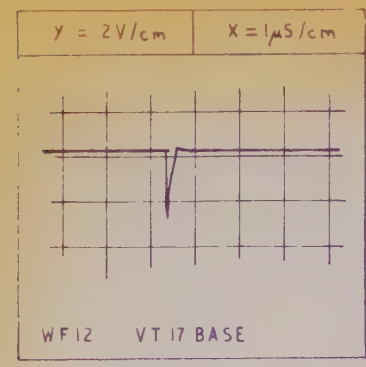
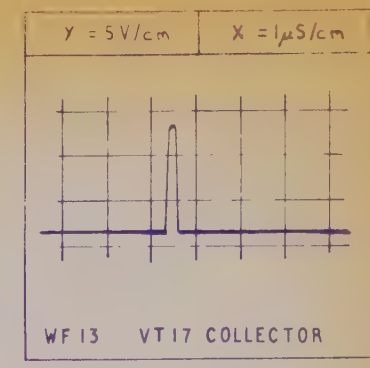
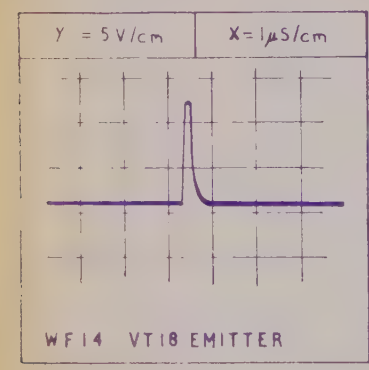
* For signal specification refer to Section 2.6



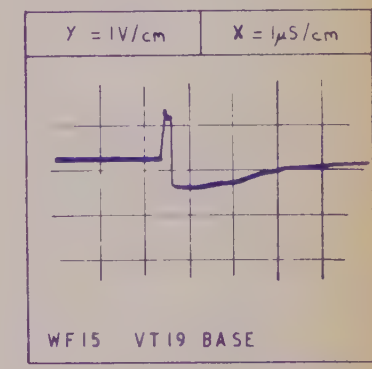
WF12 VT17 BASE



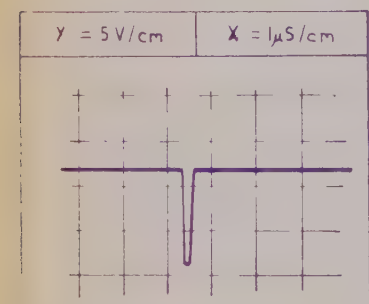
WF13 VT17 COLLECTOR



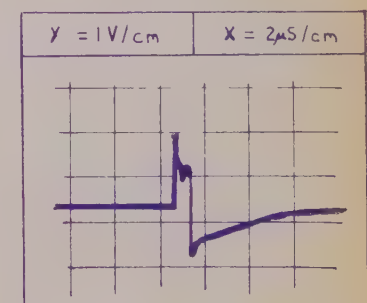
WF14 VT18 EMITTER



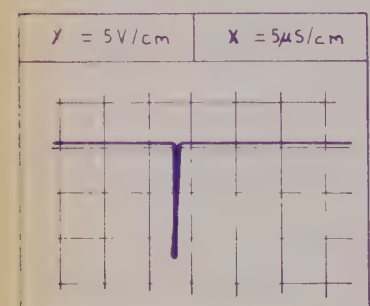
WF15 VT19 BASE



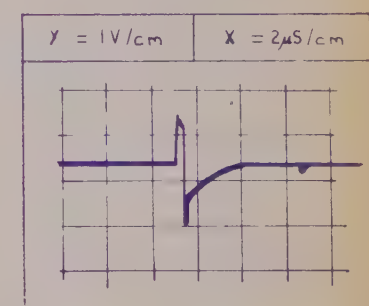
WF16 VT19 COLLECTOR



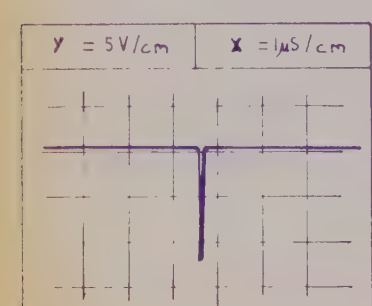
WF17 VT20 BASE



WF18 VT20 COLLECTOR



WF19 VT21 BASE



WF 20 VT21 COLLECTOR

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Check	Procedure for Fault
(i) VT22 collector: +11.5V	Low collector voltage; check VT22 for leakage and carry out check (ii).
(ii) VT23 collector not greater than +0.5V	Collector voltage high; check VT23 gain (should be greater than 60) and check RV11, 14, 15 and R70.
(iii) VT24 collector not greater than +0.5V	VT24 collector voltage high; check R72, MR28, MR29 and VT24.
(iv) VT25 collector: +11.5V	Collector voltage low; check VT25 for leakage.

(c) Set Frequency to 100 kc/s and check waveforms as shown on page 37 (i.e. waveforms WF23-29).

(1) Function of Delay Variable control restricted. Check VT23 for leakage; check RV11.

(2) Rise-times of WF25 too slow; check C45.

(3) Output pulses of VT24 or VT25 too wide or too narrow compared with waveforms WF27 & 29; check base circuit components of associated transistor.

8.2.6 Width Circuit & OR-Gate

(a) Set Frequency switch to 'Ext Input -'

(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

Y = V/cm | X = µS/cm

WF 21 VT16 BASE

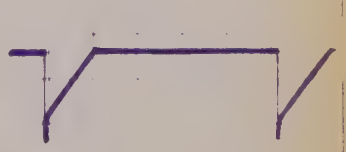
Y = 5V/cm | X = 1µS/cm

WF 22 VT16 COLLECTOR

Y = 5V/cm | X = 2µS/cm

WF 23 VT 22 COLLECTOR

Y = 5V/cm | X = 2µS/cm



WF 24 VT23 BASE

Y = 5V/cm | X = 5µS/cm

WF 25 VT 23 COLLECTOR

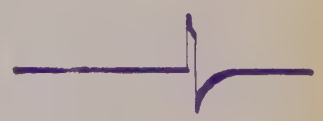
Y = 2V/cm | X = 1µS/cm

WF 26 VT 24 BASE

Y = 5V/cm | X = 1µS/cm

WF 27 VT 24 COLLECTOR

Y = 1V/cm | X = 1µS/cm



WF 28 VT 25 BASE

Y = 5V/cm | X = 1µS/cm

WF 29 VT 25 COLLECTOR

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Check	:	Procedure for Fault
(i) VT26 collector : +11.5V		Low collector voltage; check VT26 for leakage and carry out check (ii).
(ii) VT27 collector not greater than +0.5V		Collector voltage high; check VT27 gain (should be greater than 60) and check RV16, 19, 20 and R81.
(c) Set Frequency to 100 kc/s and check waveforms as shown on page 40 (i.e. waveforms WF30-33).		(1) Function of Width variable control restricted; check VT27 for leakage; check RV16 (2) Rise time of WF33 too slow; check C53.

8.2.7 Output Shapers & Inverter

(a) Set Frequency switch to 'Ext Input +'

(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

Check	:	Procedure for Fault
(i) VT28 collector approx.+10V (Main pulse polarity switch set to +)		Collector voltage low; check C61, check VT27 collector voltage (see Section 8.2.6) and check VT28 for leakage.
(ii) VT29 collector not greater than +0.5V (Main pulse polarity switch set to +)		Collector voltage high; check switch connections SE2a stator 2 (refer Dgm. S63/52), check R86 & VT29.
(c) Set Frequency to 100 kc/s and check waveforms as shown on page 40 (i.e. waveforms WF34-37).		(1) Rise time of VT28 output (WF35) too slow; check C59.

(2) Rise time of VT29 output (WF37) too slow; check C61.

(3) No output pulse from VT28 or VT29; check transistors VT28 and VT29

8.2.8 Output Stages

(a) Set Frequency switch to 'Ext Input +'

(b) Check the following d.c. conditions and refer to right hand column for procedure should fault condition be found.

N.B. Voltage values with respect to chassis-earth.

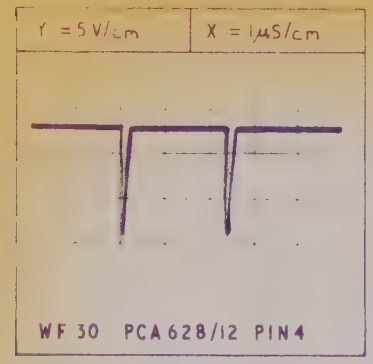
Check	Procedure for Fault
(i) VT30 collector: approx. +2V.	Collector voltage low; check VT30 for leakage.
(ii) VT30 emitter: -10V	
(iii) VT31 collector between +1V & +2V	Collector voltage high; check RV21 & R92.
VT32 collector approx. -2V	Collector voltage low; check VT32 for leakage.
VT32 emitter: +11.5V	
VT33 collector: between -1V & -2V	Collector voltage high; check RV22 and R99.

(c) Set Frequency to 100 kc/s and check waveforms as shown on page 42 (i.e. waveforms WF38-45).

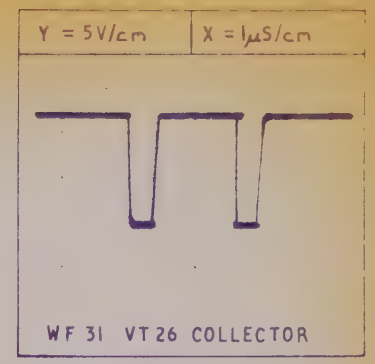
(1) VT30 permanently cut-on; check MR33.

(2) VT30 output cut-off late; check MR35.

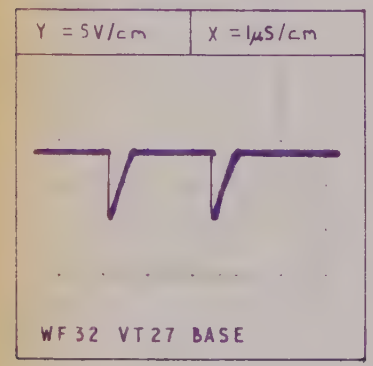
(3) VT31 output rise-time too slow; check setting of RV21 (see Section 6.2.6); check MR36, VT31 and associated components.



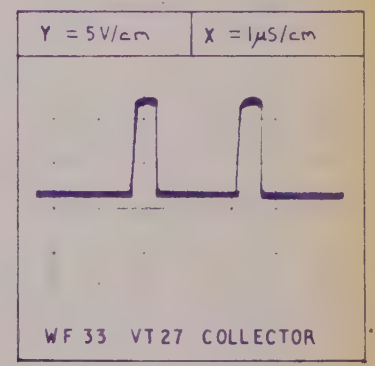
WF 30 PCA 628/12 PIN 4



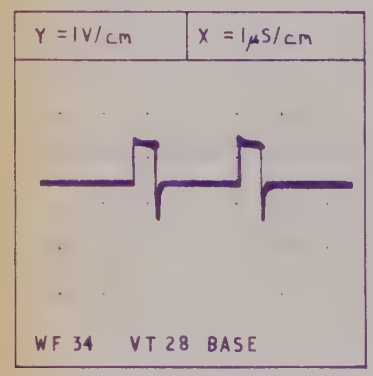
WF 31 VT 26 COLLECTOR



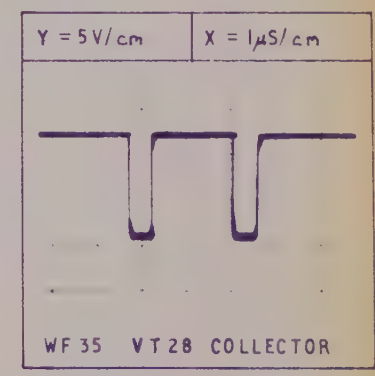
WF 32 VT 27 BASE



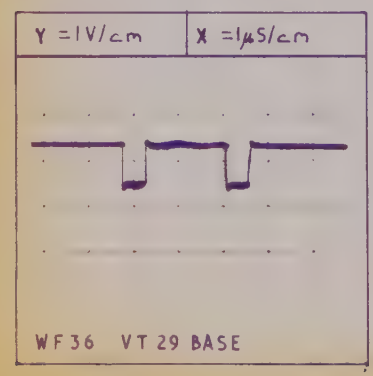
WF 33 VT 27 COLLECTOR



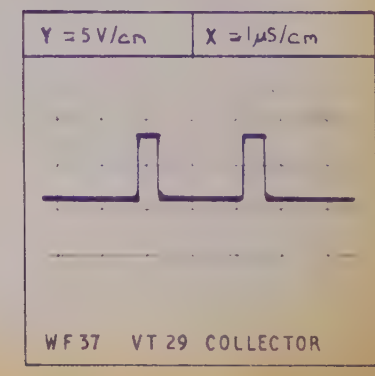
WF 34 VT 28 BASE



WF 35 VT 28 COLLECTOR



WF 36 VT 29 BASE



WF 37 VT 29 COLLECTOR

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(4) VT32 output pulse cut-off late; check MR37

(5) VT33 output rise-time too slow; check RV22 setting (see Section 6.2.6), MR39, VT33 and associated components.

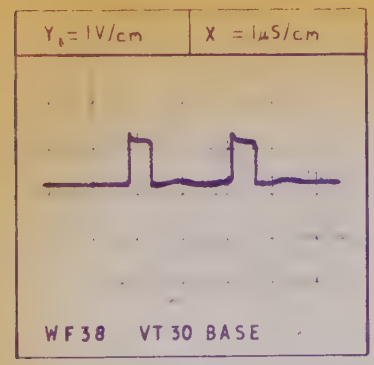
8.2.9 Power Supplies

Instructions for setting the voltages of the three H.T. supplies (Circuit diagram ES66/11) are given in Section 6.2.2.

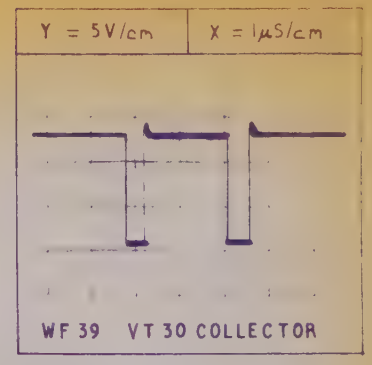
Should a fault condition be encountered, the following tests may be conducted.

Fault	:	Procedure for Fault
(i) No output from the three supply circuits.		If indicator lamp is not illuminated. check mains fuse FS1 (see Section 5.3) and check that mains input is present at transformer (T1) primary. If necessary, check lead connections (Section 3.1), switch SE (see Dgm.S63/52) and outputs of T1 secondary windings. Check transformer voltage setting (Section 3.1) then fuses FS2, FS3 and FS4 (Section 5.3).
(ii) No output from one or two supplies.		Check associated fuse FS2, FS3 or FS4 (Section 5.3). Check output of associated bridge-rectifier circuit:- Across C1* : approx. 28V d.c. " C6* : " 17V d.c. " C11* : " 17V d.c. If voltage incorrect, check corresponding rectifier and capacitor. If components are in order check circuit voltages as below.

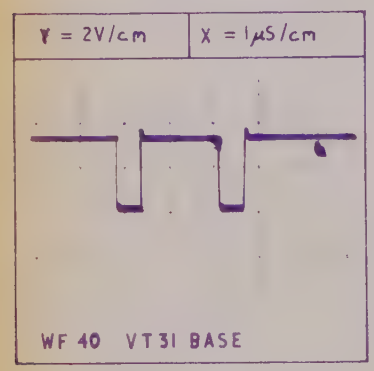
* Negative terminal :- junction of capacitor and fuse.



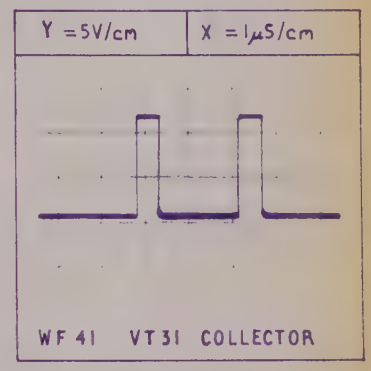
WF 38 VT 30 BASE



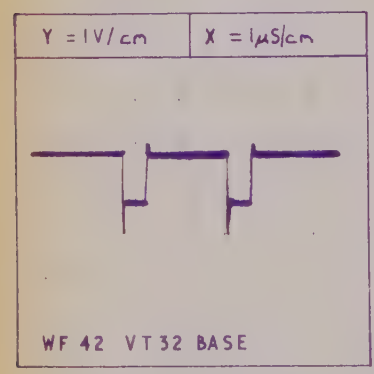
WF 39 VT 30 COLLECTOR



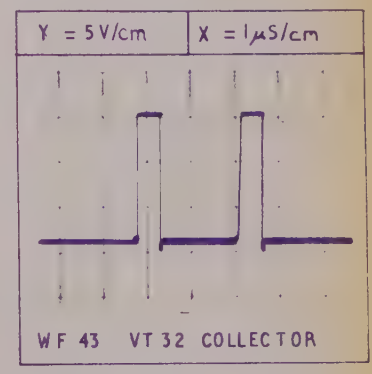
WF 40 VT 31 BASE



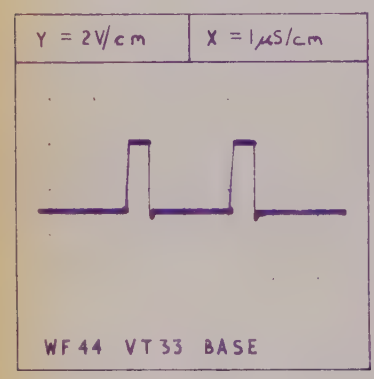
WF 41 VT 31 COLLECTOR



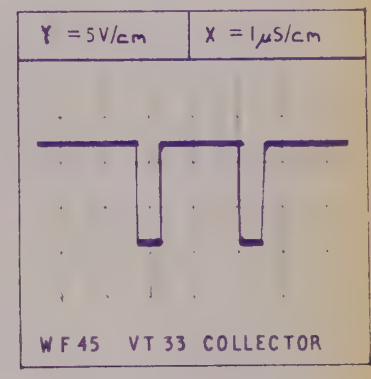
WF 42 VT 32 BASE



WF 43 VT 32 COLLECTOR



WF 44 VT 33 BASE



WF 45 VT 33 COLLECTOR

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Voltages within Stabilizer Circuits.

N.B. Voltage values with respect to chassis-earth except where stated otherwise.

Circuit fed via:-

MR1 (21.5V H.T. Supply)	MR5 (11.5V H.T. supply)	MR9 (10V H.T. supply)
VT1 collector approx.+28V.	VT4 collector approx.+17V.	VT7 collector approx. +17V*
VT1 emitter: +8 to +21.5V**.	VT4 emitter: +11.5V set by RV1.	VT7 emitter +10V* set by RV2.
VT1 base : +8.7 to+22.2V.	VT4 base approx. +21.1V .	VT7 base approx. +10.6V*
VT2 base & emitter: +9.4 to +22.9V .	VT5 base & emitter: approx. +12.8V .	VT8 base & emitter approx. +11.3V*
VT3 collector " " "	VT6 collector " "	VT9 collector " "
MR2/R5 junction +5.6V ± 5% .	MR6/R10 junction +5.6V ± 5%	MR10/R17 junction +5.6V* ± 5%

Should voltage values not conform to above table, check components of associated circuit.

9. CIRCUIT DESCRIPTION

9.1 POWER SUPPLIES (Dgm. ES66/11)

Diagram ES66/11 provided at the rear of this manual shows the mains input circuit and the three direct current power supplies employed within the instrument.

Both 'live' and 'neutral' lines of the mains input (Red-core: live, Black-core: neutral, Green-core: chassis-earth) are switched by SE3 (a & b) and a 250mA anti-surge fuse FS1 is incorporated in the 'live' supply line to transformer T1.

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*With respect to Pin 2 of PCA 628/12 board.

**Set by RV3,4&5.

Three H.T. supplies are derived from separate secondary windings of T1 via bridge-rectifiers (MR1,5 & 9) and conventional stabilizer circuits in which the reverse breakdown voltage of a silicon Zener diode (MR2,6 & 10) is employed as reference source.

In each stabilizer circuit a potentiometer is incorporated as output voltage control (RV1, 2 & 3) and a 500mA fuse (FS2,3 & 4) is connected in the positive return line.

The three circuits are arranged to provide the following supplies:-

Circuit Incorporating Rectifier:	Output Pins of Board PCA628/11	Stabilized Output
MR1	Pin 3 (+) see Footnote. " 5 (-)	21.5V
MR5	Pin 6 (+) " 7*(-)	11.5V
MR9	Pin 1*(+) " 2 (-)	10V

For the 21.5V supply circuit, the Amplitude variable control RV3 (connected to the Amplitude Board PCA628/13) functions as output voltage control, whilst preset potentiometers RV4 & 5 with resistors R20 & 21 govern the voltage range over which RV3 is functional.

Indicator lamp ILP1 is series-connected with 75Ω resistor R27 between pins 10 and 11 of the power supply board. The lamp is powered by a 16V a.c. output of T1 (i.e. that used to supply rectifier MR9).

Note: The 21.5V positive line is connected to chassis-earth when the main pulse polarity switch is set to '-'; the negative line is connected to chassis-earth when the switch is set to '+'.

* Connected to chassis-earth.

9.2 MAIN CIRCUIT (Dgm. ES66/12)

The main circuit of the instrument is shown on diagram ES66/12 provided at the rear of this manual. (Note. A block schematic diagram of the circuit is also provided : dgm.S63/54).

For the purpose of description the circuit will be treated in distinct sections as follows.

9.2.1 Oscillator

The circuit incorporating transistors VT10-VT12 is that of a variable frequency Wien-bridge oscillator which serves as internal frequency source.

Components selected at switch-wafers SA4-6 (a & b) when the Frequency switch SA is set to positions 5 to 10, together with the setting of the Frequency variable control (ganged potentiometers RV8 & 9) determine the frequency of oscillation. The circuit, which employs complementary amplifiers VT10-VT11, is gain/temperature controlled by thermistors TH1 and TH2 connected in the feedback loop from output emitter follower VT12.

Sinusoidal oscillator-output signals at the selected frequency and of amplitude approximately 4V peak-to-peak are fed to the Trigger Circuit via the rotor of switch SA1 when the Frequency switch is set to positions 5 to 10.

9.2.2 Trigger Circuit & Inverter VT16

This circuit employs emitter follower VT13 and Schmitt trigger stage VT14-15: it is operated by signals selected by the rotor of Frequency switch wafer SA1.

On switch position 1 a positive trigger signal occurs at VT13 base when, upon depression of the Manual push-button SH, C35 discharges.

Signals applied to the 'Ext. Input' socket SKTA operate the circuit when switch SA1 is set to position 2 (-) or position 3 (+). On switch positions 5 to 10 the circuit is triggered by signals from the oscillator (Note: switch position 4 unused.)

Diodes MR15 & 16 serve as input signal limiters for emitter follower VT13 which is connected between the -10V and +11.5V supply lines: the base is normally held at approximately chassis-earth level by potential divider chain R42, 43 & RV10, whilst the emitter is normally held at approximately -0.7V.*

The setting of switch SA2 (a wafer of the Frequency/Trigger selector) determines the trigger polarity, which is 'positive' on positions 1 & 3 but 'negative on the remaining positions.

Negative:

For switch SA2 positions 2 & 5-10, VT14 is normally conductive whilst VT15 is cut-off. Upon receipt of a negative-going signal at VT13 base, diodes MR18 & 19 conduct to operate the trigger circuit; VT14 is cut-off and VT15 is cut-on.

The negative-going signal produced at VT15 collector is selected (as input for the following Shaper circuit) by the rotor of switch SA3.

Positive:

On switch SA2 positions 1 & 3, diodes MR18 & 19 are by-passed by a short circuit link: VT14 is normally held non-conductive by the base biasing circuit R47 (connected to the +11.5V line) and R46 (connected to VT13 emitter: potential approx. -0.7V), therefore VT15 is held conductive. Upon receipt of a

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* With respect to chassis-earth

positive-going signal at VT13 base, the potential at VT14 base swings positive cutting on VT14 which in turn cuts off VT15. The resultant positive-going signal produced at VT15 collector is inverted by VT16 and is selected (as input for the following Shaper circuit) by the rotor of switch SA3.

9.2.3 Trigger-pulse Shaper & Emitter Follower (VT17,VT18): Pre-Pulse.

Transistor VT17 functions as pulse shaper for signals received from the trigger circuit via the rotor of switch SA3 and capacitor C40: the transistor is normally bottomed due to the base biasing circuit - R55, MR21 & 22.

Upon receipt of a negative-going signal at SA3 rotor, VT17 is cut-off for a period of approximately 200ns due to the differentiating action of C40 and base biasing resistor R55. The resultant positive pulse produced at VT17 collector is applied to emitter follower VT18.

From the emitter of VT18 the signal is passed via one of the following circuits, viz:-

i) Via pre-pulse polarity switch SG stator 1 and C69 to pre-pulse output socket SKTB. The signal constitutes the positive pre-pulse.

ii) Via inverter VT19 and pre-pulse polarity switch SG stator 2 and C69 to socket SKTB. The inverted signal constitutes the negative pre-pulse.

The postiive pulse produced at VT18 emitter is also used to trigger both the delay and width circuits which are treated in Sections 9.2.4 and 9.2.5 of this manual.

9.2.4 Trigger-pulse Inverter VT21; Delay Circuit & Shapers VT24 & 25.

The positive trigger pulse produced at VT18 emitter (see Section 9.2.3) is subjected to the differentiating action of

C44-R64: the resultant signal is inverted by VT21 so that a negative pulse of width approximately 100ns occurs at the collector. The leading edge of the pulse triggers the delay monostable circuit VT22-VT23 via diode MR27.

When the monostable is triggered, VT22(normally non-conductive) is cut-on whilst VT23 is cut-off. The circuit remains in the triggered condition for a duration (delay period) determined by the setting of the Delay switch SB (1 & 2) and Delay variable control RV11. The delay period is dependent upon the time constant of the CR-circuit formed by the VT22-collector to VT23-base coupling capacitor (selected at switch wafer SB2a) and the resistance between VT23-base and the +11.5V supply line; the value of resistance depends upon the preset potentiometer selected at switch wafer SB2b.

At the end of the delay period the monostable reverts to the stable condition (i.e. VT22 cut-off; VT23 conductive). The negative-going trailing-edge of the resultant pulse at VT23 collector, operates pulse shaper circuit VT24-VT25 which serves to produce a negative pulse of width approx. 100ns at VT25 collector. The latter signal is applied to CR-gate R76, MR31&25 treated in Section 9.2.5.

9.2.5 Trigger-pulse Inverter VT20; CR-gate & Width Circuit.

The positive trigger pulse produced at VT18 emitter (see Section 9.2.3) is subjected to the differentiating action of C43-R62: the resultant signal is inverted by VT20 and is applied to CR-gate R76, MR31&25 when mode selector switch SF is set to position 1 (Double).

The width circuit is identical to the delay circuit: VT26-27 form the monostable whilst the duration forwhich the circuit remains in the triggered condition (this duration constitutes the 'width' of each main output pulse) is determined by the setting of Width switch SC and Width variable control RV16.

In Single pulse mode (SF set to position 2) monostable VT26-27 is triggered by the negative-going edge of the pulse initiated by the delay circuit, produced at VT25 collector and applied via diodes MR31 & 32.

In Double pulse mode (SF set to position 1) the monostable is triggered twice*; firstly by the negative-going edge of the trigger-pulse inverter (VT20) output pulse, applied via diodes MR25&32, and secondly, at the end of the delay period, by the negative-going edge of the pulse produced at VT25 collector and applied via diodes MR31 & 32. It is required that the Width setting be less than the Delay setting in order that monostable VT26-27 shall have reverted to the stable state before the second trigger pulse occurs.

Pulses produced at VT27 collector are applied to pulse shaper VT28.

9.2.6 Pulse Shaper VT28 & Output Circuits.

The circuit of VT28 operates as pulse shaper for output signals received from the width circuit (i.e. from VT27 collector). Negative pulses approximately rectangular and possessing rise and fall times in the order of 20ns (pulse width determined by Width settings), are produced at VT28 collector. These signals are passed via one of two output circuits, selection of which depends upon the setting of output polarity switch SE.

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* i.e. twice between consecutive pre-pulses.

The output circuit selected for negative polarity (SE2a position 3) is formed by transistors VT32-33 and is effectively the complement of the other output circuit selected for positive polarity (SE2a & SE2b position 2) and incorporating transistors VT30-31, for which VT29 serves as input inverter.

The 21.5V H.T. supply is used to power the final stage of each output circuit (VT31; VT33). The supply is applied to the circuits by means of switch wafers SE1b and SE1c; the positive line of the supply is connected to chassis-earth when the circuit of VT33 is selected for negative output polarity, whilst the negative line is connected to chassis-earth when the circuit of VT31 is selected.

Potentiometer RV3 shown on diagram ES66/11, i.e. voltage control potentiometer of the 21.5V supply, serves as the Amplitude variable control. The Amplitude switch or attenuator is treated in Section 9.2.7.

Since both output circuits function in a similar manner, only the operation of the circuit for negative pulse output will be described.

Normally VT32 is held cut-off whilst VT33 conducts due to the base to -10V supply line connection formed by R100, RV22& R99. Upon receipt of a negative pulse at VT32 base, the collector potential tends to that of the +11.5V supply line and hence VT33 is cut-off by reverse emitter to base bias, the value of which is limited by R98, 100 & 101. To achieve fast switching action, saturation of VT32 & VT33 is avoided by the use of diodes MR37 & MR39 respectively. The action of series-connected diodes MR11, 14

(SE1a pos.3)prevents the collector to emitter potential of VT33, which remains due to non-saturation, from being applied to the following circuit (i.e. the attenuator); therefore the centre-pin of output socket SKTC is normally held at chassis-earth potential.

9.2.7 Attenuator

Signals from the selected output circuit (VT30-31 or VT32-33) are applied to the attenuator by means of switch wafer SD1a (i.e. a wafer of the Amplitude switch SD). The attenuator circuit comprises the printed circuit Attenuator board PCA628/14 (components R22-26) and resistors R103-106: the attenuator network is tapped by the rotor of switch wafer SD1b connected to output socket SKTC. Amplitude-switch positions 1 to 5 correspond to the 0.5, 1, 2, 5 and 10 volt ranges respectively, whilst on switch position 6 the signals from the output circuit are fed directly to SKTC; the latter setting corresponds to the 20V range.

The attenuator is designed to provide an output impedance of 50Ω on the first five ranges and 100Ω on the sixth (20V) range.

10. CIRCUIT REFERENCES

10.1 CIRCUIT REFERENCE (Drg. ES66/11):

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Capacitors:-						
C1	1000µF	-	50V	S63/51 Fig.1	C6	Y20643/31
C2	100µF	-	25V	"	B8	" /34
C3	0.1µF	-		"	B10	Y23914/27
C4	100µF	-	25V	"	C9	Y20643/34
C5	500µF	-	"	"	D9	" /28
C6	2000µF	-	"	"	B5	" /32
C7	100µF	-	"	"	A4	" /34
C8	"	-	"	"	C4	" /34
C9	"	-	"	"	D7	" /34
C10	500µF	-	"	"	C7	" /28
C11	1000µF	-	"	"	D5	" /33
C12	100µF	-	"	"	B10	" /34
C13	"	-	"	"	C10	" /34
C14	"	-	"	"	C10	" /34
C15	500µF	-	"	"	D10	" /28
Diodes:-						
MR1	1B 15 P05	-	-	S63/51 Fig.1	C3	Z20648/11
MR2	BZY88/C5/V6	-	-	"	C8	X20639/30
MR3	10AS	-	-	"	B4	" /13
MR4	"	-	-	"	A4	" /13
MR5	1B 15 P05	-	-	"	A3	Z20648/11
MR6	BZY88/C5/V6	-	-	"	C6	X20639/30
MR7	10AS	-	-	"	C4	" /13
MR8	"	-	-	"	D4	" /13
MR9	1B 15 P05	-	-	"	D3	Z20648/11
MR10	BZY88/C5/V6	-	-	"	C11	X20639/30
Fuses:-						
FS1	250mA	Anti-surge		S63/51 Fig.1	D1	Z50291
FS2	500mA			"	D6	Z19831
FS3	"			"	A5	"
FS4	"			"	D8	"

CIRCUIT REFERENCE (Drg.ES66/11) continued

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Indicator Lamp:-						
ILP1	12V	-	1W	-	-	Z22749
Resistors:-						
R1	3Ω	±10%	3W	S63/51 Fig.1	B10	Z21092/3
R2	1kΩ	"	½W	"	B9	X20635/6
R3	1kΩ	"	"	"	B8	" /6
R4	2.2kΩ	"	"	"	B9	" /9
R5	1.8kΩ	"	"	"	B8	" /8
R6	1.5 Ω	"	3W	"	B7	Z21092/14
R7	1kΩ	"	½W	"	B7	X20635/6
R8	"	"	"	"	B7	" /6
R9	"	"	"	"	B7	" /6
R10	"	"	"	"	C7	" /6
R11	330Ω	"	"	"	B8	" /42
R12	1kΩ	"	½W	"	B8	" /6
R13	1.5Ω	"	3W	"	B11	Z21092/14
R14	1kΩ	"	½W	"	B11	X20635/6
R15	"	"	"	"	B11	" /6
R16	"	"	"	"	B11	" /6
R17	"	"	"	"	C11	" /6
R18	330Ω	"	"	"	C11	" /42
R19	1kΩ	"	"	"	C11	" /6
R20	100Ω	"	"	S63/52	Amp.Board	" /44
R21	100Ω	"	"	"	" "	" /44
R27	75Ω	"	3W	"	" "	Z21092/15
Res.Variable:-						
RV1	1kΩ		½W	S63/52	A8	X20999/31
RV2	1kΩ			"	D11	" /31
RV3	1kΩ			"	Switch SD	" /43
RV4	1kΩ			"	Amp.Board	" /31
RV5	1kΩ			"	" "	" /31

CIRCUIT REFERENCE (Drg. ES66/11) continued

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Transistors:-						
VT1	40250	-	-	S63/51 Fig.1	A9	X20638/60
VT2	BSX21	-	-	"	A9	" /64
VT3	BSX21	-	-	"	C9	" /64
VT4	40250	-	-	"	A6	X20638/60
VT5	BSY38	-	-	"	A6	" /59
VT6	BSY38	-	-	"	C7	" /59
VT7	40250	-	-	"	A11	" /60
VT8	BSY38	-	-	"	A11	" /59
VT9	BSY38	-	-	"	C11	" /59
Transformer:-						
T1	Mains			S63/51 Fig.1	B2	Y50236

10.2 CIRCUIT REFERENCE (Drg.ES66/12)

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Capacitors Variable:-						
C16	4-60pF	-	-	S63/52	Switch SA	Z21135/5
C17	"	-	-	"	" SB	"
C18	"	-	-	"	" SA	"
C19	"	-	-	"	" SB	"
Capacitors:-						
C20	620pF	± 2%	-	S63/52	Switch SA	Y20641/30
C21	6800pF	"	-	"	"	Y20644/8
C22	0.068µF	"	-	"	"	Y23914/25
C23	0.68µF	"	-	"	"	" /26
C24	6.8µF	± 5%	-	"	"	Y22776/9
C25	6.8µF	"	-	"	"	" /9
C26	0.68µF	± 2%	-	"	"	Y23914/26
C27	0.068µF	"	-	"	"	" /25

CIRCUIT REFERENCE (Drg. ES66/12) continued

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Capacitors(contd.):-						
C28	6800pF	± 2%	-	S63/52	Switch SA	Y20644/8
C29	620pF	"	-	"	"	Y20641/30
C30	47 pF	± 10%	-	"	"	Y20641/ 15
C31	2000µF	-	12V	S63/50	C5	Y20643/27
C32	0.1µF	-	-	"	A4	Y23914/27
C33	100µF	-	25V	"	C4	Y20643/34
C34	10pF	-	-	"	E1	Y20641/17
C35	4µF	-	15V	"	D1	Y20643/3
C36	0.1µF	-	-	S63/52	Fig.2	Y23914/27
C37	47pF	± 10%	-	S63/50	E3	Y20641/15
C38	80pF	-	-	"	D3	" /10
C39	47pF	-	-	"	E2	" /15
C40	47pF	-	-	"	B6	" /15
C41	47pF	-	-	"	C6	" /15
C42	0.1µF	-	-	"	B6	Y20614/27
C43	80pF	-	-	"	B7	Y20641/10
C44	47pF	-	-	"	B7	" /15
C45	60pF	-	-	"	E5	" /9
C46	1µF	± 2%	-	S63/52	Switch SB	Y23914/12
C47	0.1µF	"	-	"	"	" /11
C48	0.01µF	"	-	"	"	" /10
C49	1000pF	± 2½%	-	"	"	Y20641/29
C50	33pF	-	-	"	"	" /14
C51	80pF	-	-	S63/50	A7	" /10
C52	47pF	-	-	"	A8	" /15
C53	60pF	-	-	"	D8	" /9
C54	1µF	± 2%	-	S63/52	Switch SC	Y23914/12
C55	0.1µF	"	-	"	"	" /11
C56	0.01µF	"	-	"	"	" /10
C57	1000pF	± 2½%	-	"	"	Y20641/29
C58	33pF	-	-	"	"	" /14
C59	22pF	-	-	S63/50	D8	" /16

CIRCUIT REFERENCE (Drg. ES66/12) continued

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Capacitors (contd.):-						
C60	1µF	-	-	S63/50	A9	Y23914/28
C61	10pF	-	-	"	A10	Y20641/17
C62	1µF	-	-	"	B11	Y23914/28
C63	100µF	-	25V	"	E11	Y20643/34
C64	0.1µF	-	-	"	E11	Y23914/27
C65	0.1µF	-	-	"	D9	" /27
C66	100µF	-	25V	"	F10	Y20643/34
C67	0.1µF	-	-	"	E9	Y23914/27
C68	80pF	-	-	"	C9	Y20641/10
C69	390pF	-	-	S63/52	Fig.2	Y20641/8
C70	60pF			"	Switch SB	" /9
C71	220pf			"	" SA	" /15
Diodes:-						
MR11	IS44	-	-	S63/52	Amp.Board	X20639/31
MR12	"	-	-	"	"	"
MR13	"	-	-	"	"	"
MR14	"	-	-	"	"	"
MR15	2052	-	-	S63/50	E4	X20639/32
MR16	"	-	-	"	F4	" /32
MR17	Unused	-	-			
MR18	2052	-	-	S63/50	F3	" /32
MR19	"	-	-	S63/50	F3	"/32
MR20	"	-	-	"	C4	"/32
MR21	"	-	-	"	A6	"/32
MR22	"	-	-	"	A6	"/32
MR23	IS44	-	-	"	C6	"/31
MR24	IS44	-	-	"	C7	"/31
MR25	IS44	-	-	"	D7	"/31
MR26	IS44	-	-	"	D6	"/31

CIRCUIT REFERENCE (Drg. ES66/12) continued

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Diodes (contd.)						
MR27	IS44	-	-	S63/50	D6	X20639/31
MR28	2052	-	-	"	B7	" /32
MR29	"	-	-	"	B7	" /32
MR30	IS44	-	-	"	A8	" /31
MR31	IS44	-	-	"	B8	" /31
MR32	"	-	-	"	C8	" /31
MR33	ZB10	-	-	"	B9	" /22
MR34	IS44	-	-	"	C9	" /31
MR35	"	-	-	"	C9	" /31
MR36	"	-	-	"	D11	" /31
MR37	"	-	-	"	B9	" /31
MR38	"	-	-	"	B9	" /31
MR39	"	-	-	"	D10	" /31
Resistors:						
R22	1.5kΩ	± 10%	½W	TSA628/7/1	Atten.Board	X20635/7
R23	100Ω	± 5%	"	"	"	X50500/25
R24	120Ω	"	"	"	"	" /27
R25	120Ω	"	"	"	"	" /27
R26	82Ω	"	"	"	"	" /23
R28	1.5kΩ	± 10%	"	S63/50	C4	X20635/72
R29	330Ω	"	"	"	B3	" /42
R30	100Ω	"	¼W	"	C2	X50500/25
R31	330Ω	"	½W	"	C1	X20635/42
R32	3.3kΩ	"	"	"	B1	" /10
R33	47Ω	"	"	"	B3	" /34
R34	3.3kΩ	"	"	"	B3	" /10
R35	820Ω	"	"	"	B3	" /5
R36	330Ω	"	"	"	B3	" /42
R37	1kΩ	"	"	"	B4	" /6
R38	270Ω	"	"	"	B4	" /2
R39	1kΩ	"	"	"	B3	" /6
R40	1.8kΩ	"	2W	"	E1	Z50256
R41	470Ω	"	½W	"	D1	X20635/3

CIRCUIT REFERENCE (Drg.ES66/12) continued.

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Resistors (cond.) :-						
R42	33kΩ	±10%	½W	S63/50	E4	X20635/3
R43	22kΩ	,,	,,	,,	F4	,,/19
R44	1kΩ	,,	,,	,,	F4	,,/6
R45	2.7kΩ	,,	,,	,,	F3	,,/54
R46	1.8kΩ	±5%	½W	,,	F3	X50500/55
R47	7.5kΩ	,,	,,	,,	E3	,,/70
R48	47Ω	±10%	½W	,,	D4	X20635/3
R49	33Ω	± 5%	½W	,,	D4	X50500/13
R50	2.2kΩ	± 10%	½W	,,	D3	X20635/9
R51	3.3kΩ	,,	,,	,,	D3	,,/10
R52	220Ω	,,	1W	,,	E3	X20652/26
R53	3.3kΩ	,,	½W	,,	D3	X20635/10
R54	330Ω	,,	,,	,,	D3	,,/42
R55	6.8kΩ	,,	,,	,,	A6	,,/14
R56	560Ω	,,	,,	,,	A6	,,/50
R57	330Ω	,,	,,	,,	B6	,,/42
R58	3.3kΩ	,,	,,	,,	C6	,,/10
R59	1kΩ	,,	,,	,,	B6	,,/6
R60	470Ω	,,	,,	,,	C6	,,/3
R61	10kΩ	,,	,,	S63/52	Fig.2	,,/16
R62	3.3kΩ	,,	,,	,,	B7	,,/10
R63	330Ω	,,	,,	,,	C7	,,/42
R64	3.3kΩ	,,	,,	,,	C6	,,/10
R65	330Ω	,,	,,	,,	D6	,,/42
R66	3.3kΩ	,,	,,	,,	D5	,,/21
R67	470Ω	,,	,,	,,	D6	,,/3
R68	5.6kΩ	,,	,,	,,	D5	,,/13
R69	330Ω	,,	1W	,,	D6	X20652/25
R70	470Ω	,,	½W	,,	E5	X20635/3
R71	4.7kΩ	,,	,,	,,	E6	,,/12
R72	3.3kΩ	,,	,,	,,	A7	,,/10
R73	330Ω	,,	,,	,,	A7	,,/42
R74	3.3kΩ	,,	,,	,,	A8	,,/10
R75	330Ω	,,	,,	,,	B8	,,/42

CIRCUIT REFERENCE (Dgm.ES66/12)continued.

Circuit Reference	Value or Type	Tol.	Rating	Layout Diagram	Location on Dgm.	Venner Part No.
Resistors (cond.) :-						
R76	1kΩ	±10%	½W	S63/52	B8	X20635/6
R77	270Ω	,,	1W	,,	C7	X20652/28
R78	33kΩ	,,	½W	,,	D8	X20635/21
R79	5.6kΩ	,,	,,	,,	C8	,,/13
R80	330Ω	,,	1W	,,	C8	X20652/25
R81	470Ω	,,	½W	,,	E8	X20635/3
R82	4.7kΩ	,,	,,	,,	D8	,,/12
R83	2.2kΩ	,,	,,	,,	C8	,,/9
R84	560Ω	,,	,,	,,	D8	,,/50
R85	220Ω	,,	1W	,,	B8	X20652/26
R86	2.2kΩ	,,	½W	,,	A10	X20635/9
R87	560Ω	,,	,,	,,	B10	,,/50
R88	220Ω	,,	1W	,,	B10	X20652/26
R89	220Ω	,,	½W	,,	B10	X20635/1
R90	150Ω	,,	,,	,,	C10	,,/46
R91	47Ω	,,	1W	,,	C10	X20652/27
R92	100Ω	,,	2W	,,	C11	Z50257
R93	82Ω	,,	½W	,,	C11	X20635/47
R94	82Ω	,,	,,	,,	D11	,,
R95	100Ω	,,	6W	,,	E11	Y50235
R96	270Ω	,,	½W	,,	B9	X20635/2
R97	82Ω	,,	,,	,,	B9	,,/47
R98	47Ω	,,	1W	,,	C9	X20652/27
R99	100Ω	,,	2W	,,	D9	Z50257
R100	82Ω	,,	½W	S63/50	D10	X20635/47
R101	82Ω	,,	,,	,,	D10	,,
R102	100Ω	,,	6W	,,	E10	Y50235
R103	56Ω	,,	1W	S63/52	Switch SD	X20652/21
R104	91Ω	±5%	¼W	,,	,,	X50500/24
R105	82Ω	,,	,,	,,	,,	,,/23
R106	82Ω	,,	,,	,,	,,	,,

CIRCUIT REFERENCE (Dgm.ES66/12) continued.

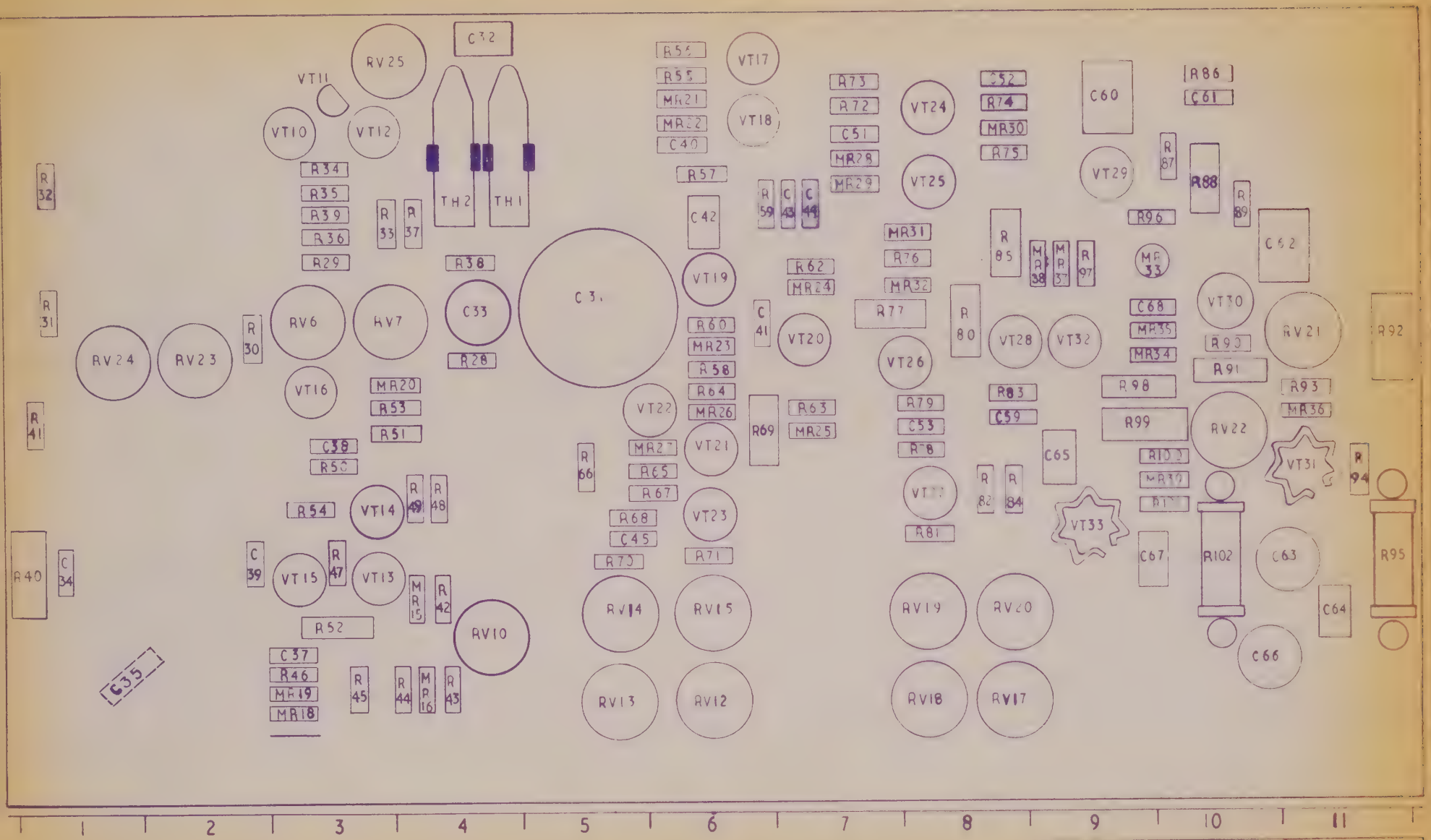
Circuit Reference	Value or Type	Tol.	Rating	Layout on Dgm.	Location on Dgm.	Venner Part No.
Res. Variable						
RV6	1kΩ	-	-	S63/50	C3	X20999/31
RV7	"	-	-	"	C3	" /31
RV8*	10kΩ	-	-	S63/52	Switch SA	X20999/33
RV9*	10kΩ	-	-	S63/52	"	
RV10	68kΩ	-	-	S63/50	E4	X20999/34
RV11	15kΩ	± 5%	-	S63/52	Switch SB	" /42
RV12	1kΩ	-	-	S63/50	F6	" /31
RV13	"	-	-	"	F5	" /31
RV14	"	-	-	"	E5	" /31
RV15	"	-	-	"	E6	" /31
RV16	15kΩ	± 5%	-	S63/52	Switch SC	" /42
RV17	1kΩ	-	-	S63/50	F8	" /31
RV18	"	-	-	"	F8	" /31
RV19	"	-	-	"	E8	" /31
RV20	"	-	-	"	E8	" /31
RV21	"	-	-	"	C11	" /31
RV22	"	-	-	"	D10	" /31
RV23	"	-	-	"	C2	" /31
RV24	"	-	-	"	C1	" /31
RV25	6.8kΩ	-	-	"	A3	" /32
Socket						
SKTA	-	-	-	-	-	X20637/96
SKTB	-	-	-	-	-	"
SKTC	-	-	-	-	-	"
Switch						
SA	-	-	-	-	-	Y50237
SB	-	-	-	-	-	Y50238
SC	-	-	-	-	-	Y50238
SD	-	-	-	-	-	Y50239
SE	-	-	-	-	-	Y50240
SF	-	-	-	-	-	Z27067
SG	-	-	-	-	-	"
SH	-	-	-	-	-	X50296

* RV8 & RV9 ganged

CIRCUIT REFERENCE (Dgm. ES66/12) continued.

Circuit Reference	Value or Type	Tol.	Rating	Layout on Dgm.	Location on Dgm.	Vernier Part No.
Thermistors						
TH1	R52	-	-	S63/50	B4	Y23955/5
TH2	R53	-	-	"	B4	" /3
Transistors						
VT10	BSY38	-	-	S63/50	A3	X20638/59
VT11	V405A	-	-	"	A3	" /65
VT12	BSY38	-	-	"	A3	X20638/59
VT13	"	-	-	"	E3	" /59
VT14	BSY95A	-	-	"	D3	" /56
VT15	BSY38	-	-	"	E3	" /59
VT16	"	-	-	"	C3	" /59
VT17	"	-	-	"	A6	" /59
VT18	"	-	-	"	A6	" /59
VT19	"	-	-	"	C6	" /59
VT20	"	-	-	"	C7	" /59
VT21	"	-	-	"	D6	" /59
VT22	"	-	-	"	D6	" /59
VT23	BSY95A*	-	-	"	D6	" /56
VT24	BSY38	-	-	"	A8	" /59
VT25	"	-	-	"	B8	" /59
VT26	BSY95A*	-	-	"	C8	" /56
VT27	" *	-	-	"	D8	" /56
VT28	BSY38	-	-	"	C8	" /59
VT29	"	-	-	"	B9	" /59
VT30	"	-	-	"	C10	" /59
VT31	MM163	-	-	"	D11	" /49
VT32	V205	-	-	"	C9	" /62
VT33	MM1614	-	-	"	E9	" /61

* Selected: Beta greater than 60



MAIN BOARD LAYOUT TSA628	S63/50
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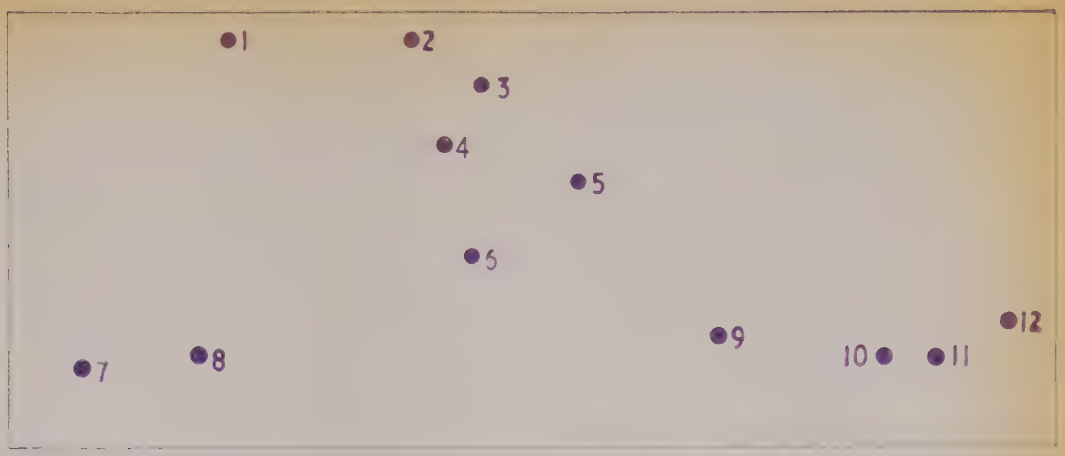
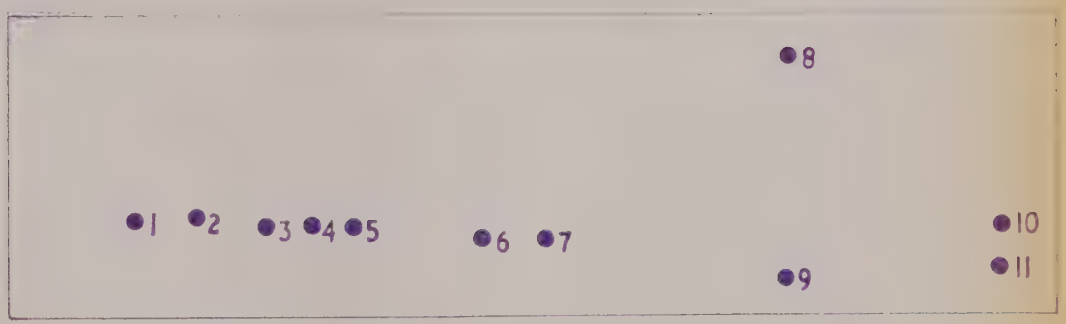


COPPER SIDE OF BOARD.

FIG. 1



COPPER SIDE OF BOARD.

FIG. 2

FIG. 1	MAIN BOARD PIN POSITIONS.
FIG. 2	POWER SUPPLY BOARD PIN POSITIONS.

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DRAWN	S.L.S.
DATE	23 3 66
APPROVED	

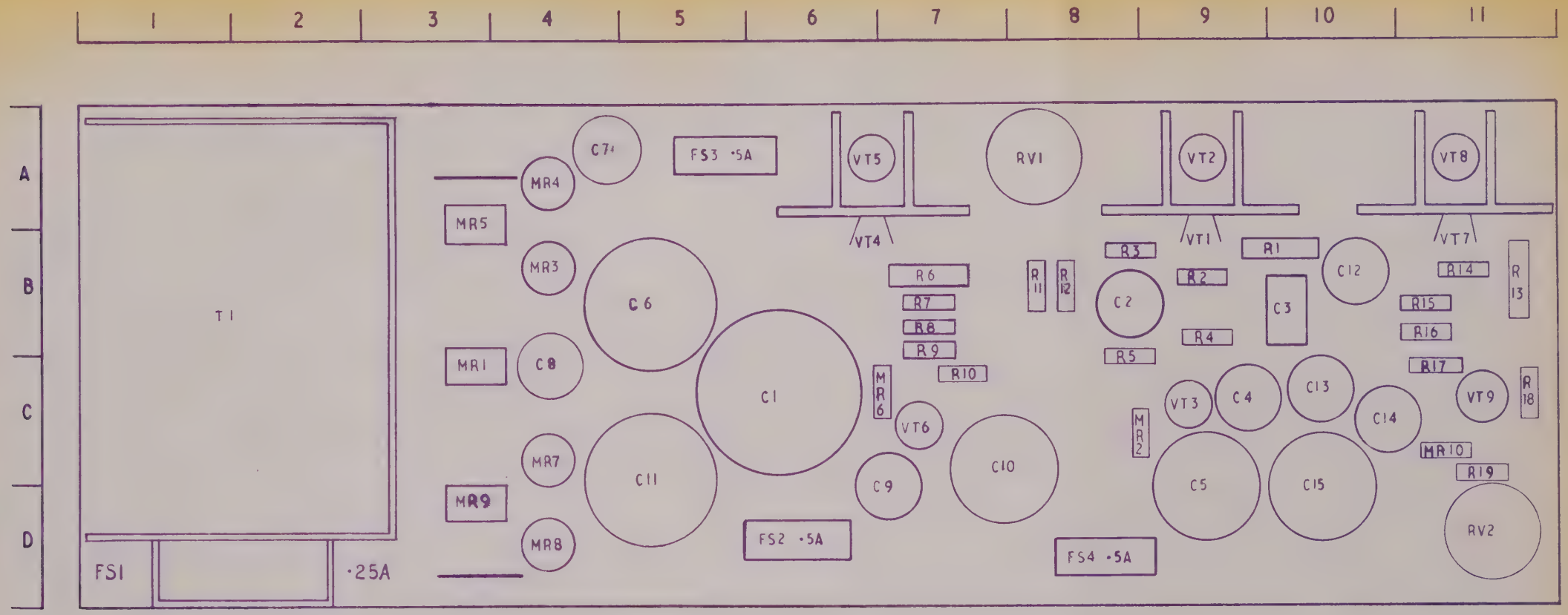

FIG. 1

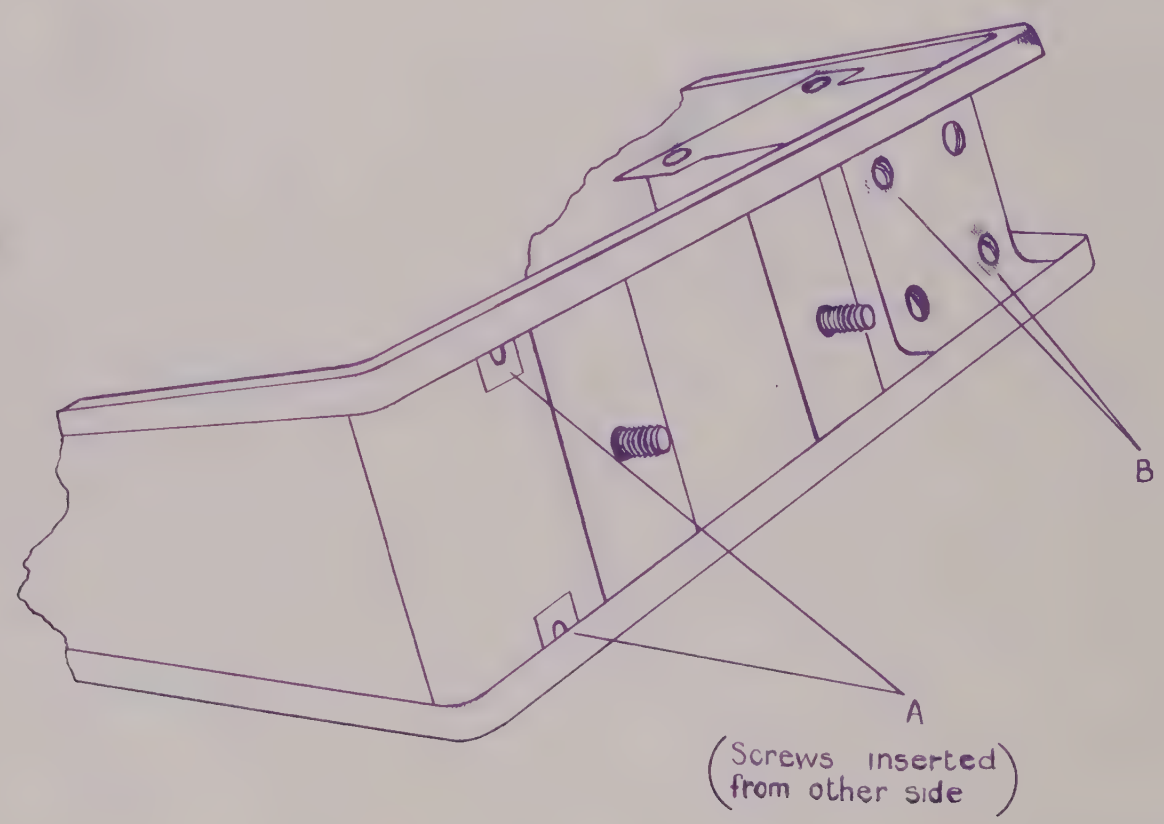

FIG. 2

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APPROVED	
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SCALE	

FIG. 1:	TSA 628 POWER SUPPLY BOARD
FIG. 2:	REAR VIEW OF FRAME
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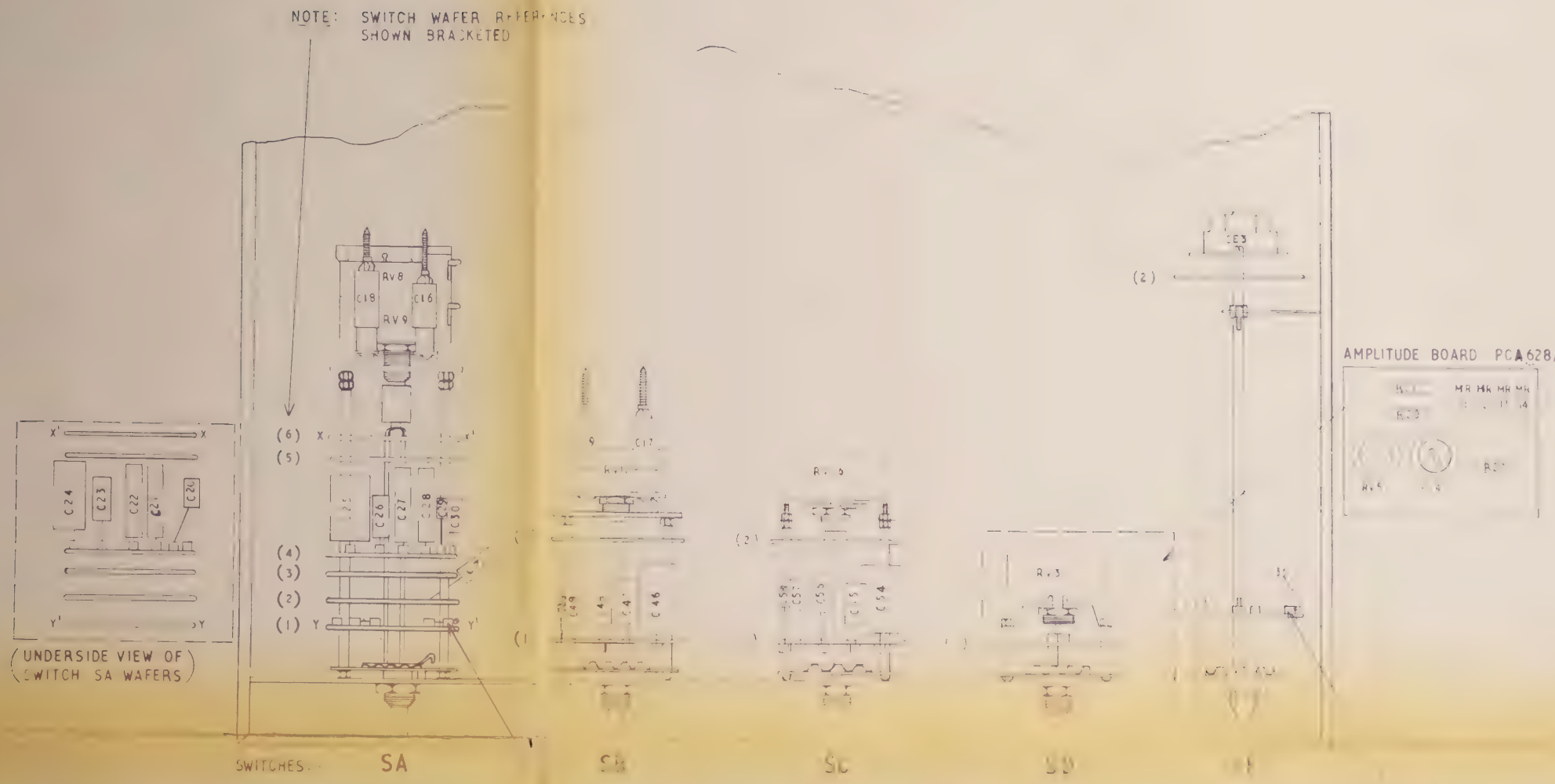


FIG. 1

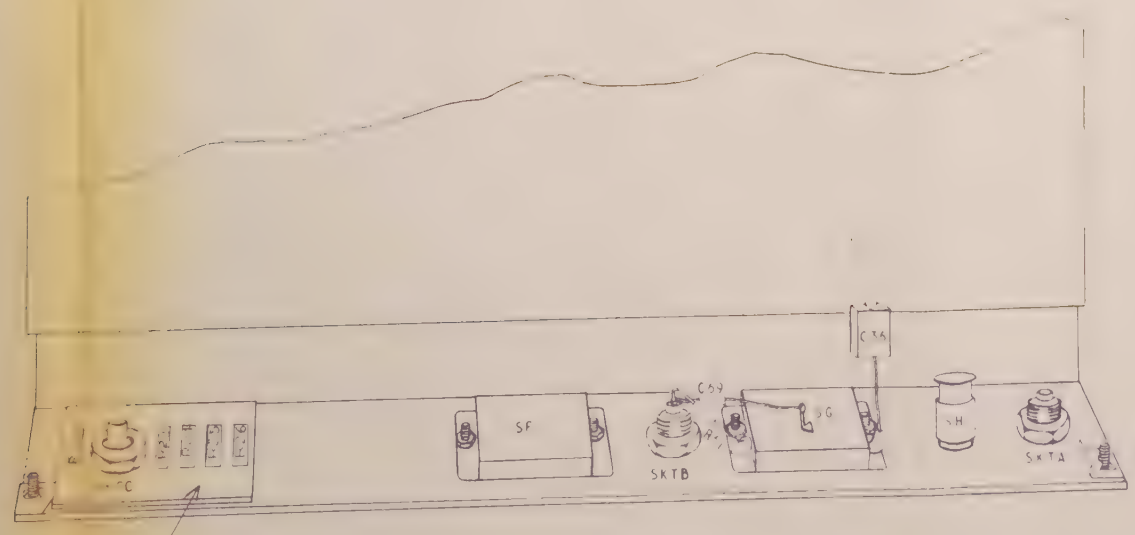
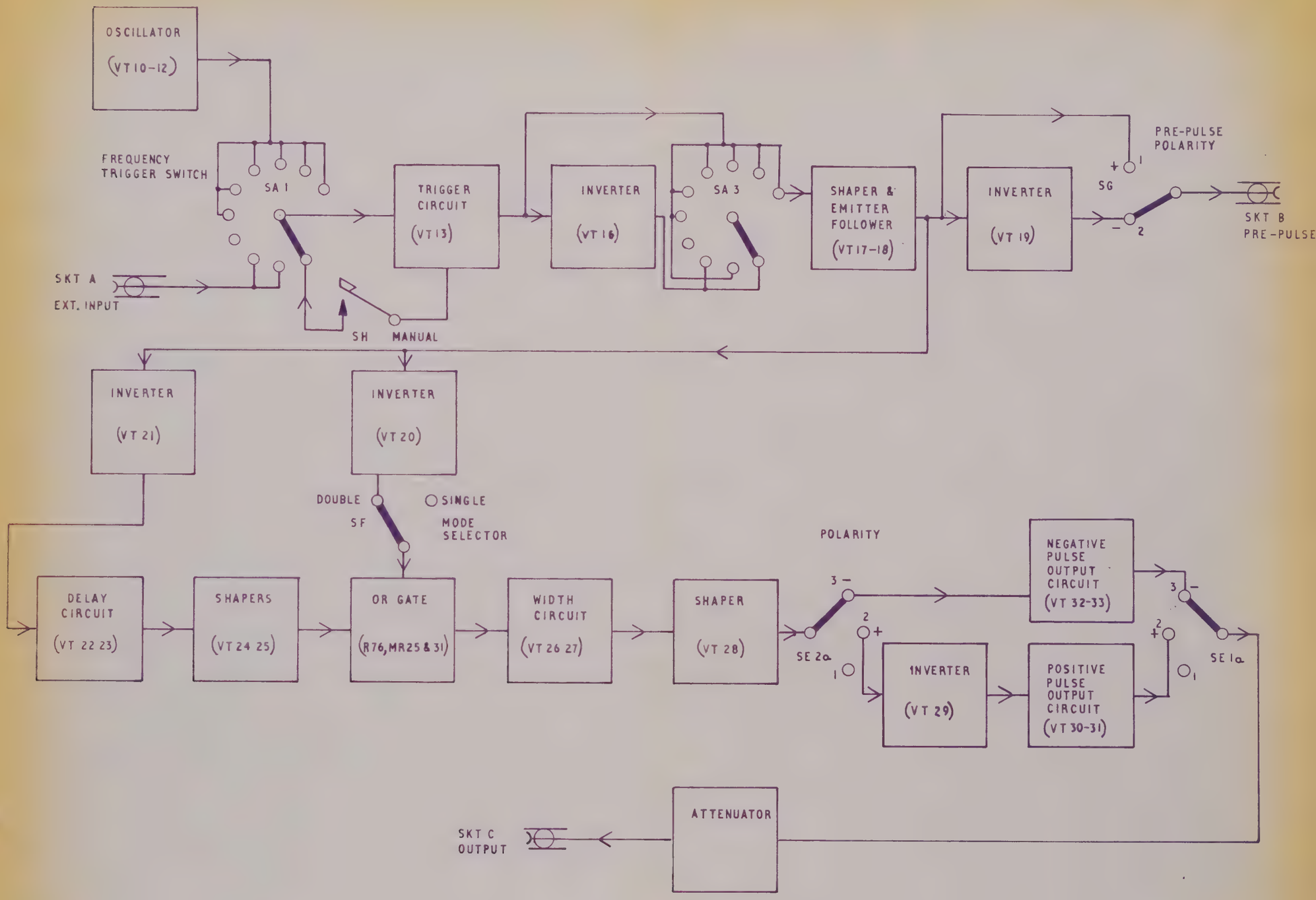


FIG. 2

FIG. 1	ROTARY CONTROLS LAYOUT TSA6
FIG. 2	UNDER-CHASSIS FRONT-PANEL-MOUNTED COMPONENTS LAYOUT

S 63/52



TSA 628 CIRCUIT BLOCK SCHEMATIC		
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DATE	4·4·66	
CHECKED		
SCALE		

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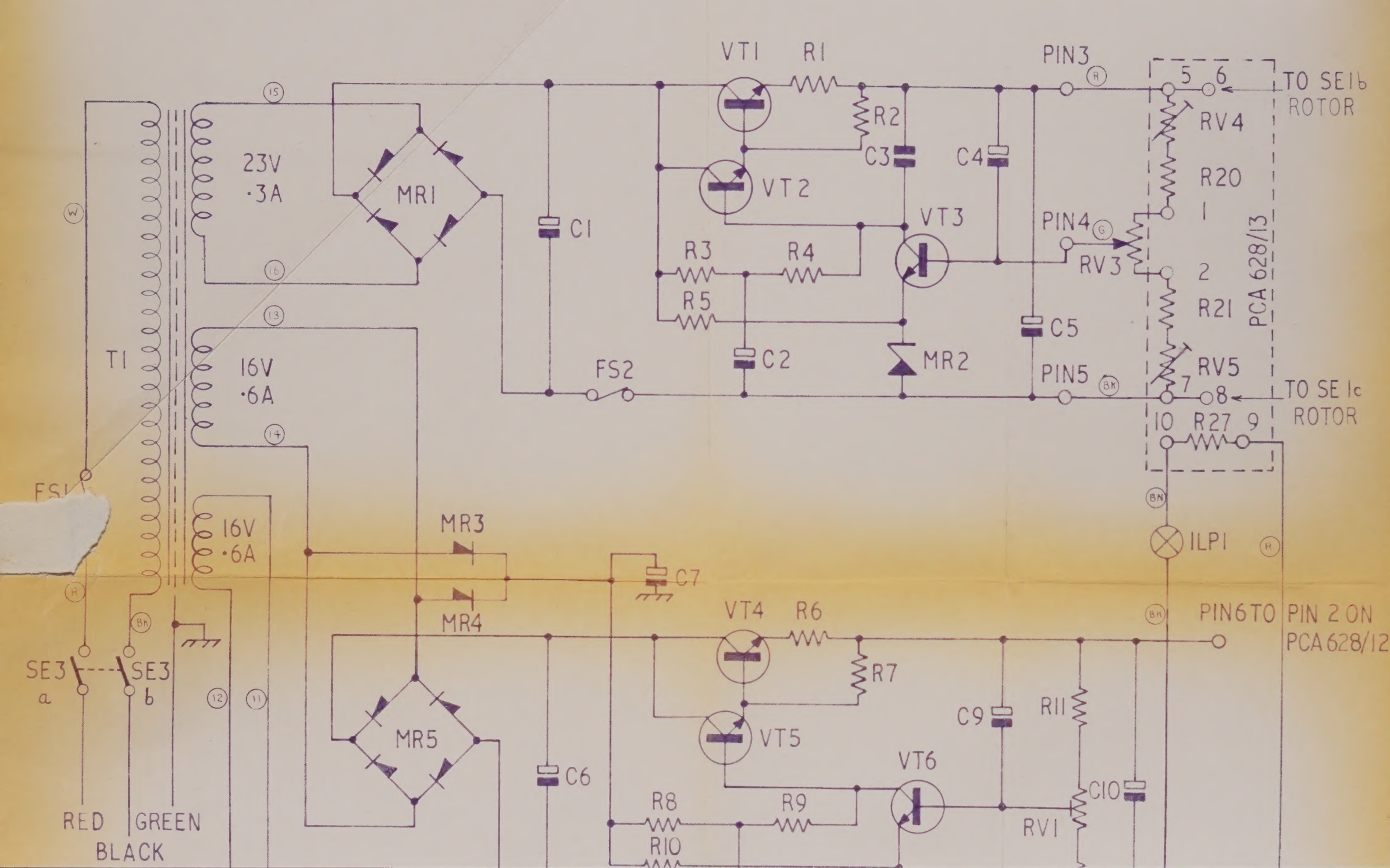
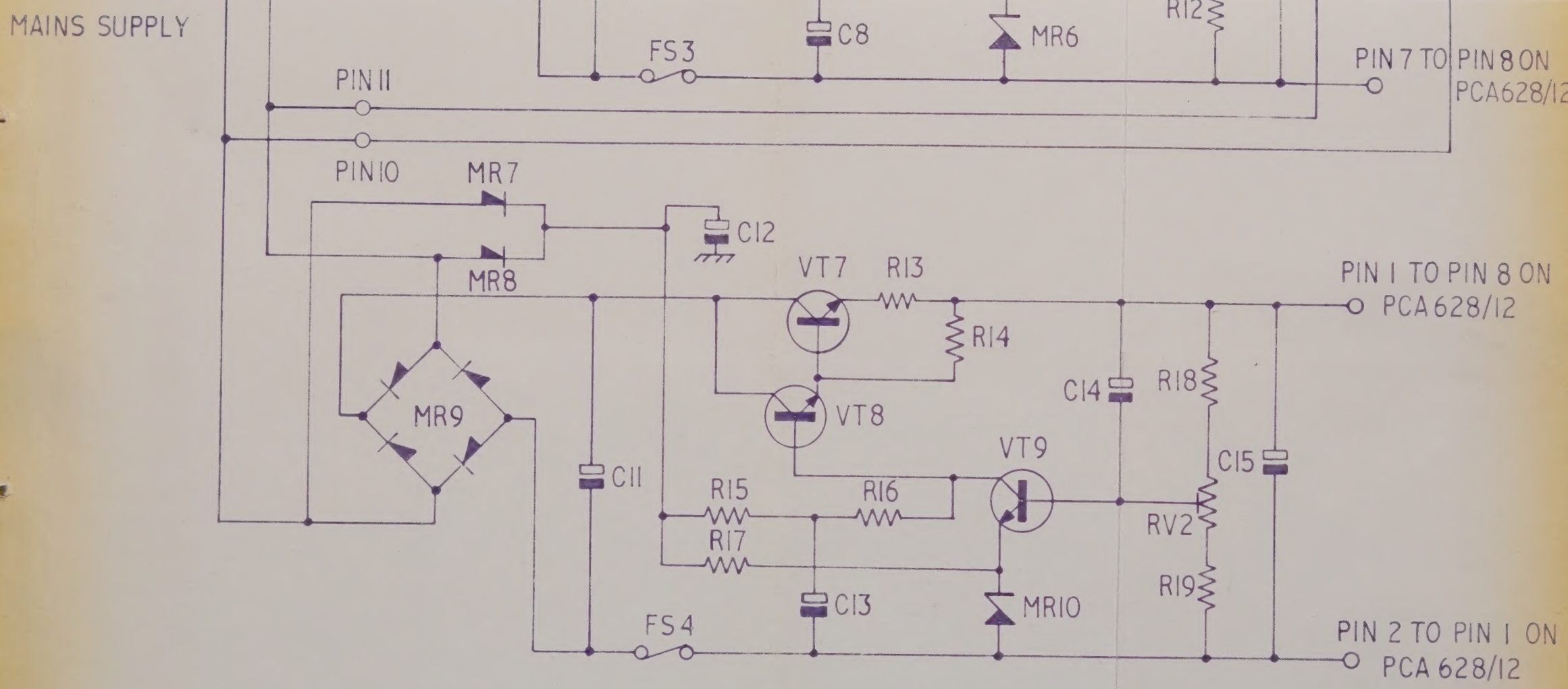

VT1
R1
PIN3
TO SE1b ROTOR
RV4
R20
1
2
R21
PCA 628/13
RV5
TO SE 1c ROTOR
R27
ILP1
R2
C3
C4
VT2
VT3
PIN4
RV3
R3
R4
R5
C5
C2
MR2
PIN5
FS2
C1
MR1
23V
·3A
T1
16V
·6A
16V
·6A
MR3
MR4
C7
VT4
R6
R7
PIN6 TO PIN 2 ON PCA 628/12
SE3 a
SE3 b
MR5
C6
VT5
VT6
C9
R11
C10
R8
R9
R10
RV1
RED
GREEN
BLACK



POWER SUPPLY FOR
TSA 628
(PCA 628/11)

DRAWN	P.L.B.	ES 66/11
APPROVED	B.W.T.	
DATE	23·8·65	

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